Vol. 36, No. 6 June, 1939

Psychological Bulletin

THE SOCIAL PSYCHOLOGY OF THE VERTEBRATES

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INTRODUCTION

In limiting the field covered by this review the term *social psychology* is defined as the study of the interactive behavior of organisms as distinguished from *sociology,* which is concerned with the behavior of groups as wholes. The experimental beginnings of the social psychology of the vertebrates will be reviewed in this paper. Almost all of the strictly experimental studies have been made during the last decade, and toward these primary attention will be directed. A number of laboratory observations and a few field studies must be included to complete the survey of the available literature relevant to this new area of study. A summary of the vast literature on the natural history of the vertebrates is obviously outside the scope of the report. Of the laboratory studies which have some bearing on social interaction, those on sex physiology and behavior are arbitrarily excluded. It is unnecessary to point out that a complete theoretical consideration of the social psychology of the vertebrates could not be made without reference to reproductive behavior.

The material to be presented has been classified according to various aspects of social behavior. These topics are regarded as convenient rather than correlative. Within each division reports on different kinds of vertebrates are grouped together, and a zoological classification [1] of the literature is offered by the arrangement of the bibliography. The majority of the studies are exploratory in nature,

[1] Division has been made according to the classes of vertebrates, except that the primates have always been given separate treatment. The term *mammals* will always be understood by the reader as excluding primates. The term *primates* refers throughout to infrahuman primates.

projected in various directions on diverse types of vertebrates. Individual review of method and content of each is therefore preferable to an attempted summary statement of the findings from the inceptive stages of this work.

Mention should be made of a number of references which include a wider range of material than is given here or which are intensive reviews of particular groups of vertebrates. A general survey of animal sociology, which places chief emphasis on descriptions of types of associations adapted to various sexual relationships, is given in Alverdes' book (**160**). Reference is made therein to the early works of Espinas, Ziegler, and Doflein, and much material is taken from Brehm's *Tierleben*. Allee (**156**) also summarizes the earlier work and offers a simplification of Deegener's (**164**) comprehensive classification of the social organization of animals. Allee introduces the experimental study of aggregations, particularly as they appear in lower organisms. He elucidates the principle of "co-operation," or automatic interdependence, among organisms, ranging from a supplementation of foodstuffs and waste products to an intraspecies teamwork. His later reviews (**157**, **158**, **159**) survey some of the same material and extend consideration to the higher forms, although they do not pretend to be exhaustive treatments of the literature. Recent books by Picard (**172**) and Rabaud (**173**) are cited as exemplifying different theoretical points of view. Special topics relative to the social behavior of animals are treated in Groos's work on play (**167**) and in Kropotkin's on mutual aid (**170**).

Articles expressing the need for a comparative social psychology are offered by Eidmann (**165**) and Maslow (**171**), while textbook discussions of the subject are given by Tinklepaugh (**174**), Warden, Jenkins, and Warner (**175**, **176**), and Katz (**169**), the last of which is noteworthy for an adequate summary of recent German work.

The social behavior of various groups of vertebrates has been given special treatment in recent biological texts (**5**, **27**) and semipopular books (**19**, **44**). The literature on anthropoid apes, covering a period from 1912 through 1925, is reviewed by Yerkes and Child (**150**). In *The great apes,* Yerkes and Yerkes (**153**) discuss all the literature available on these primates through 1929. Throughout the present paper reference will rarely be made to work included in this book. Zuckerman (**155**) covers the most important literature on primate social behavior in his *Social life of monkeys and apes.* Finally, 3 chapters in the *Handbook of social psychology* are of particular interest: Friedmann (**47**) and Alverdes (**93**) discuss, respec-

tively, the group behavior of birds and mammals, using field observations as chief source material. Yerkes and Yerkes (154) present an admirable chapter on the social life of 4 representative primates—the lemur, howler monkey, baboon, and chimpanzee, in which the field studies of Nissen (137) and Carpenter (115) are summarized in detail. To these field studies reference will be made in this paper only for special topics. The Yerkes also offer a constructive outline of areas for study in developing the experimental social psychology of primates.

Stimulus-Response Aspects of Aggregational Behavior in Lower Vertebrates

The social grouping found among lower vertebrates seems to be limited, save for mating groups, to loose associations in which little or no internal organization appears. For these Allee (156) has adopted the term *aggregations*. Aggregations have been regarded with renewed interest since the publication of Allee's book, which treats the various physical and behavioral factors that influence their formation. It may be noted in passing that the physiology of this kind of group behavior is of particular interest to the psychologist in suggesting fundamental drive mechanisms which may come to motivate social interaction during the course of phylogeny or ontogeny.

Fish. Most fish form aggregations at various times, particularly under adverse conditions. A special type of such behavior has been recognized in schooling, which Parr (9) defined as swimming together in roughly parallel courses in closely bunched groups. He distinguished between temporary or unstable schools, formed when some outside factor disturbs the fish, and stable schools, which are difficult to disperse and which seem to depend on a strong mutual attraction between individuals. Parr offered a theory of schooling behavior based on experiments showing that blinded fish do not school, in which he postulated a positive attraction between individuals which brings them within a certain range of each other, and a repellent stimulus condition arising from sensations of too close visual accommodation. Balance of stimuli from other individuals on either side tends to keep a fish on a straight course, while individuals on the outside of the school tend to be slightly oriented toward the center of the group. The theory of mutual attraction was also used to account for milling, which occurs when members of a school turn and swim about in concentric circles. In a later paper, Parr (10) recognized sex behavior as a reaction somewhat opposed to schooling. In this connection a recent review by Noble (8) of the literature on

sexual dimorphism and sexual selection among fishes should be mentioned.

Papers have recently appeared which tend to substantiate points in Parr's theory. Bowen (**1, 2**) demonstrated the primary importance of vision in catfish aggregations and the secondary use of tactual and vibratory sensitivity when some of the fish were blinded. Breder (**3**) found that certain fish would not approach a solid object nearer than a particular point, "which is probably the limit of visibility." From experiments on the effects of changes in temperature, chemical composition of water, and amount of light, Breder and Nigrelli (**4**) concluded that schooling is motivated by a "primary impulse" dependent on vision and inhibited by specific requirements, as feeding and reproduction. Mutual orientation in apparent preference to photic orientation was studied by Langlois (**6**) in bass. Spooner (**13**) found that members of this species were attracted to one another through a glass partition, or that a mirror image served as well. He also found that neither the complete form nor the movement of another fish was required to stimulate the approaching response. The course of schools taken in avoiding a projecting wall has been described in trigonometric symbols for a variety of fish by Tauti and co-workers (**14, 15, 16**).

Reptiles and Amphibia. The aggregation behavior of the small brown snake *(Storeria dekayi)* has been carefully studied in the laboratory by Noble and Clausen (**29**). Temperature and humidity conditions promoting aggregation were experimentally determined, and the use of vision as the chief sense modality, with olfaction as a secondary mode, was demonstrated. The snakes were attracted to one another by movement rather than form or color, and a mirror image was found effective as a stimulus for approach.

Concerning the social stimuli involved in the aggregations (chiefly for mating) of amphibia there seems to be no experimental evidence beyond the importance of vocalization in frogs (**27**). Aggregational behavior is also found among the higher vertebrates during seasons of breeding or migration and when influenced by various adverse physical conditions. The psychological nature of this behavior has not been studied in the laboratory, probably because the attention of experimenters has been directed toward more complex forms of social behavior.

Social Facilitation

The general term *social facilitation* may refer to any increment of individual activity which results from the presence of another indi-

vidual, and can be regarded as one of the most basic forms of social interaction. In the literature on animal behavior its meaning has been restricted to increments in the frequency and intensity of responses already learned by an individual, shown in the presence of other individuals usually engaged in the same behavior. Imitation, on the other hand, has referred to observational learning in problem situations. While social facilitation is manifestly involved in observational learning, it has been convenient in this review to distinguish between studies on social facilitation and imitation. No real dichotomy between them is implied. Since almost all of the former are concerned primarily with social factors (size of groups, dominance status of individuals, etc.), they will be given more detailed treatment than most of the imitation studies where chief emphasis is placed on the learning process.

Fish. Schuett (11) observed goldfish in groups of 1, 4, 8, and 16 individuals and found that amount of bodily activity was related, within limits, to size of group, indicating a possible factor of social facilitation. Relative oxygen consumption was controlled.

Welty (17) performed a careful series of experiments on 930 fish which demonstrated social facilitation of unlearned acts and of the simultaneous learning of simple habits by groups of fish. The subjects were chiefly goldfish, but also included pussy minnows, killifish, lake shiners, paradise fish, and zebra fish. The general methodology of the 33 experiments required a rectangular aquarium containing 1 or more wire screens, each having a hole or door in it, through which fish were trained to swim into another compartment to receive food. The chief measure of learning was the decrease in time of movement from one compartment to another. Four experiments showed that fish in groups of 2, 4, and 8 learned a single-door aquarium maze more quickly than individual fish. Four more experiments employed comparable groups of 4 individuals in 15 aquaria; to some groups a trained fish was added in the starting compartment to serve as a "leader"; with other groups an untrained fish was placed in the goal compartment to serve as a "lure"; and no other fish were added to the control groups. Results showed most rapid learning for the groups with leaders, and those with the lure fish learned faster than controls.

Unique tests of "group cohesion" were made in 6 experiments in which groups of 4 fish were placed in the central compartments of aquaria. All members of some groups were trained to swim to one compartment, while 2 members of other groups were trained to go

to the forward compartment and the other 2 to the rear compartment. Most rapid learning took place when all fish moved in the same direction. Carefully controlled experiments showed that fish consumed more food (the small crustacean *Daphnia*) when in groups of 4 than when alone. The "confusion effect," resulting from apparent inhibition of the feeding response when too many *Daphnia* were available to a single animal, may have played a large part in the results, since, when *Daphnia* were given to individual fish in groups of 100 instead of 600, they consumed as much per day as the fish in groups. In general, the results of Welty's series of well-controlled experiments leave little doubt of the susceptibility of fish to social facilitation.

Birds. Breed (**36**) made incidental observations on apparent social facilitation of drinking, and perhaps also of pecking, in the chick, and Craig (**41**) found evidence for facilitation of pecking, but not drinking, in the dove. Fletcher, Cowan, and Arlitt (**46**) found that the pecking response developed as rapidly with 4 isolated chicks as with normal chicks, therefore concluding that social facilitation was unimportant. In 1927 Fischel (**45**) made observations on a flock of 500 white leghorn hens, most of which will be treated under another topic. Social facilitation of feeding was indicated in the observation that when one hen began to eat, others, who had shown no signs of hunger previously, ran toward this one and began feeding.

Part of the evidence used by Bayer (**34**) for a 2-component theory of hunger was obtained from observations on social facilitation of feeding in hens. Using 8 hens, whose dominance hierarchy had been determined, he allowed 1 to eat at a pile of grain until apparently satiated, and then introduced a hungry hen. The satiated animal began, in every case, to eat again, consuming between 25% and 43% of the amount of food originally eaten, or an average of 34% for the group. If the satiated animal were dominant over the invader, she would attempt to prevent her from eating by pecking at her, finally beginning to eat again herself, when her pecking proved ineffective; if subordinate, she would eat again despite the pecks received from the dominant, hungry animal. Greater increments in eating were shown by a satiated animal when 3 hungry hens were introduced in place of 1, averaging 53% and ranging from 33% to 67%. Use of 3 satiated and 1 hungry animal resulted in considerably less increment of feeding in satiated animals. A fourth experiment showed that, when 4 hens ate alone and together on

alternate days, they showed social increments between 33% and 200%, averaging 96%.

Allee and Masure (32) studied the effect of the presence of one shell parrakeet (lovebird) upon the learning of a color discrimination problem by another. A total of 97 birds, 4 months old, were used until they were well past the point of sexual maturation. Birds trained in pairs learned more slowly and showed longer response times and greater variability than individual learners, regardless of the sex of the partners. Birds caged in pairs and trained alone reacted as did singly caged birds. When mastery was reached, individuals changed from the isolated to paired routine and vice versa gave performances identical with those trained under paired or isolated conditions. Mutual interference, rather than social facilitation, characterized the results; the performance of the pair approximated that of the poorer learner.

Mammals. In a number of experiments on rats Harlow (99) clearly demonstrated the effect of social facilitation on feeding. In the best controlled experiment of the series, 34 animals, weaned at 18 days, were reared in individual cages until 30 days of age. They were then paired on the basis of weight and were fed alternately in pairs and individually for 20 days. In the social situation 8% more food was eaten than in the individual, which difference was found statistically reliable. No change in amount of facilitation with practice was detected. Other experiments indicated that experience was not important to social facilitation, since rats, fed only on milk, showed the social increment when paired and fed solid food for the first time. Also, rats who were reared and fed in isolation showed facilitation on the first experimental period. Competition characterized the behavior of paired animals where social facilitation was observed; when one partner was restrained and could not compete, no increment was shown in the other's behavior. A technique adopted from Bayer, in which a rat already fed for an hour was joined by a hungry animal, failed to increase the former's eating over what would have been eaten during a second hour had it been left alone. Harlow's discovery that facilitation scores were no greater with groups of 3 than groups of 2 rats differed from the findings of Bayer with the hen.

Studies by Lepley (103) and Bruce (96) indicated social facilitation of running in rats, while Waters (108) found no evidence for facilitation of maze learning. Lepley gave individuals of 2 groups,

of 6 littermates each, 20 preliminary runs, and 80 untimed runs in a 30-foot runway, after which 40 timed runs were allowed, and pairings were made on the basis of speed. Each pair was given 40 timed runs to the goal box, where each animal received food. Animals in pairs ran slightly faster than when alone. A competitive situation was arranged for the following 160 runs, in which only the winning animal was rewarded. Losers of early trials seldom won later, except in a few trials at the very end. Bruce's results were obtained when paired rats were allowed to run a free pathway to a drinking fountain. An increase in running speed and amount of water drunk followed an initial decrease in pairs of experienced rats. Pairs of naïve rats showed initial increase of speed, while those paired with experienced animals ran faster, covered less distance, drank more water, and took less time for the first drink than naïve rats tested alone. Waters employed 2 sets of 2 matched groups of 20 rats each on 2 forms (elevated and alley) of the Miles unidirectional maze, members of one group running one maze singly and another in pairs. Median errors and time per run failed to differentiate results from paired and isolated animals.

Primates. Social facilitation of feeding was studied in 3 pairs of 6 rhesus monkeys by Harlow and Yudin (**127**). In the 4 experimental situations employed, there were placed in an observation chamber (1) a cage containing both animals and the food pan (direct competition); (2) 2 cages, 1 foot apart, with 1 animal and a food pan in each (noncompetitive); (3) 2 cages, 1 foot apart, with 1 animal and a food pan in each and an additional food pan between the cages available to each subject (combined competitive and noncompetitive); and (4) 2 cages placed next to one another so that the monkey in each might reach into the food pan in the other cage ("robber" situation). Tests with the 3 pairs of monkeys extended over 10 days in each situation, odd days serving as controls. When orange was used, the situations yielded percentages of social facilitation in the order listed above: (1) 13%, (2) 23%, (3) 53%, and (4) 69%, although all subjects did not always show the effect. When a less preferred food—bread—was used in situation (1) the percentage of facilitation was 152. Harlow suggested that since orange was greatly preferred to bread [subjects ate 962 pieces of orange and 75 of bread during the control periods of situation (1)], it was "liked" and eaten without need of a secondary stimulus. The qualitative data did not indicate that any clear attitudes of dominance or subordination were manifested between members of the pair.

These data are comparable to those of the same author on the rat and suggest how much more susceptible the monkey is to facilitation, even when competition is eliminated. Observations on feeding behavior of other pairs of monkeys reported in this paper, which indicate "envy" in Bayer's terminology, will be cited in the section on dominance.

Yerkes' (**148**) study of extraspecies suggestibility in the chimpanzee may be considered under the general topic of social facilitation of feeding, although here the social stimulus was the experimenter. Twenty-one animals, 4 males and 17 females, ranging in age from infancy to mid-maturity, were offered pieces of filter paper on 4 successive days. The extent to which they accepted it as foodstuff was rated on a 5-point scale ranging from (0) refusal to accept or prompt rejection without carrying it to lips to (4) eager acceptance, chewing, and swallowing with evident satisfaction. Average scores for the 4 preliminary trials were 36, 23, 26, and 20. On experimental days, as the filter paper was given the animal, the experimenter simultaneously took a piece, drew it into his mouth, and chewed it noisily. Scores for these days were 18, 27, 27, 24. A trend toward extinction of the eating response was thus arrested by the experimental procedure, indicating the operation of social facilitation from the experimenter.

Imitation

By far the greatest number of experimental studies of imitation were made between the years 1900 and 1913, when interest in the process as a demonstration of animal intelligence, as well as a unique mode of problem solution, was at its height. Some 20 studies from this period are adequately summarized in Watson's (**177**) chapter on "The Abridgement of the Learning Process" (pp. 277–296). A more recent review of imitation in the vertebrates is given by Warden, Jenkins, and Warner (**176**), and by Spence (**140**) for the primates. Only the most recent studies will be treated here. Attention is called to Ball's recent report (**112**) of a case of apparent imitation in a monkey who lived with a cat and drank in typical cat fashion.

Fish. Welty's (**17**) work on fish included 4 experiments in which a single-unit maze was placed in the wider compartment of a longitudinally divided rectangular aquarium, and a fish was allowed to observe, from the narrower compartment, another fish swimming through the maze 10 or 20 times. Tested 1 hour later, the observing

fish swam the maze faster than controls who were prevented from seeing the maze by an opaque screen. A special checking procedure, in which food was presented in the goal compartment at intervals, but in which no demonstrating animal performed, indicated that a real facilitation of the learning process, or a type of imitation, had occurred.

Mammals. An interesting experiment, representing a type of imitation, or at least social conditioning, was performed on 7 pairs of dogs by Kriazhev (102). With food or shock used as the primary stimulus, 1 dog of each pair was conditioned to a metronome or bell while the other was neither fed nor shocked, but only perceived the secondary stimuli given the first dog. When food was used, conditioned secretory responses, the stability of which lay intermediate between CR's of the first and second order, appeared in the observing animal. With shock, a rise in general excitability and conditioned respiratory change was shown by the observing dog, as was also the case in the food situation. Presence of another animal facilitated the formation of conditioned responses in the subject receiving the primary stimuli. No mention is made of dominance relation between subjects, so that results may not be compared with those of James (100), reported in the section on dominance, which were obtained under somewhat similar experimental conditions.

Primates. A unique methodology, which primarily emphasized social factors in imitation, was used by Aronowitsch and Chotin (111). The results of tests with it, however, were somewhat disappointing. From a group of 20 rhesus monkeys observed in a cage, the 2 most dominant and 5 others were selected, the most dominant being placed in cage A and the 6 others in cage B. The monkey in cage A was trained to open a food box when a door was raised exposing a red light, and to inhibit the response when a blue light appeared. For training of the 6 in cage B the signals were reversed, and 3 of them, who did not learn in the allotted time, were eliminated. Seventeen tests of imitation were made on 5 days by first testing the animals in each cage to insure presence of original training, and then removing an opaque screen between the cages and exposing signal lights in view of all animals. The results of many social test series were inconclusive because, on the preliminary tests, animals in each cage failed to react according to training. In one series of tests, of unreported number, 2 of the 3 followed the dominant monkey on half the trials, and the third on none of the trials, while the dominant was reported to have followed the group on 44% of the trials. On tests

with the screen in place, subsequent to this series, animals in each cage reacted according to training. Tests should be repeated with this interesting methodology, using a greater number of animals of varied social characteristics.

The most convincing demonstration of imitative learning in the monkey or any other animal was given by Warden and Jackson (**144**), using a methodology designed to meet the criteria of intelligent imitation stated by Warden, Jenkins, and Warner (**175**, p. 256). These criteria are: "(a) the general pattern of the required response must be sufficiently complex and novel; (b) the response must appear consistently from mere observation, opportunity for practice being altogether excluded; (c) the performance of the imitator must be substantially the same as that of the imitatee; and (d) a sufficient number of instances under varied conditions must occur to eliminate the chance factor." Warden and Jackson used 2 adjacent cages, each of which contained identical, simple problem boxes. For a demonstration trial the box in the demonstrator's cage was illuminated by a spotlight and he opened it 5 times in full view of the imitator. This light was turned off in the demonstrator's compartment and another spotlight illuminated the imitator's problem box, which he was given 60 seconds to open.

Four problems were devised by using different fastenings on the problem-box door; 15 animals served as imitators, while a single monkey did all the demonstrating. On every problem each imitator was given a complete series of 6 groups of 5 demonstration trials, followed by 1 imitation test, regardless of his success or failure on the early imitation tests for each problem. For an animal who opened his box on the first imitation test, subsequent tests could be only tests of retention, yet the authors gave these equal weight with the first tests in reporting the general figure of 46.3% " immediate imitation." In the present writer's opinion this figure should be reduced to between 20% and 25%, depending on how certain doubtful cases are scored. Spence (**140**) has also criticized this study on the ground that the factor of enhancement of the stimulus was not entirely ruled out.

Crawford and Spence (121) recently have reported a new method for studying imitation which employed discrimination learning as problem material. A chimpanzee previously trained in discrimination learning was given a series of opportunities to observe another animal's discriminations between a pair of stimuli and then to make critical, irregularly rewarded choices for himself. The authors

argued that this technique is superior to the problem-box method because learning is limited to a single connection between an already mastered manipulation habit and a visual stimulus, and because, by varying the combination of form stimuli, problems may be set which are known to be within the individual learning ability of the imitator, yet novel to him. Of the 3 experimental techniques used, which differed in procedures for rewarding the imitator on demonstration trials, only the one in which the imitator received no reward on demonstration trials can be considered a real test of imitation. Eleven test series made on 9 animals with this technique yielded unambiguous positive results in only 1 case and partial learning in others. The problem for the imitator was too difficult to make practicable a longer series of tests.

Dominance

More attention has been given by experimenters to social dominance in vertebrates than to any other single topic treated in this review. Although the early writers were clearly aware of the phenomenon, particularly in birds (**48, 92**), it remained for the Norwegian scientist, Schjelderup-Ebbe, to elucidate the principle of hierarchies, in his 1922 paper on domestic chickens. Since then, investigations have been made on every group of vertebrates save the fish and amphibia. Fighting and defense of territory have been described in the fish (**7, 18**), and doubtless someone will soon attempt to work out a dominance hierarchy with members of this group.

As a fundamental criterion applicable to all vertebrates, dominance status is indicated by superiority in fighting ability of one individual over one or more species-mates. It is often impractical to observe all fighting which may take place within a group of animals under observation, so that in certain investigations relative dominance status has been inferred from other behavioral indices or indirect measures adapted to the peculiarities of the species. As more complex vertebrates are studied it is possible that more diverse manifestations of dominance status will be recognized in the individual. It is therefore important to discover how many behavior patterns of a single animal may indicate dominance, and to what extent they are correlated. A high correlation between a number of behavioral indices might indicate that dominance can be considered as an attitude which influences all the social behavior of the individual.

Exploration of the significance of the concept of dominance has hardly begun, since little is known as yet about how dominance

relations may influence all sorts of social interaction. Also, the factors which determine dominance status are yet to be fully elucidated. Among the primates the subject is particularly fascinating, since there the relation between dominance and sex behavior is perhaps most striking. Full exploration of this relationship may suggest solutions for many baffling problems of sex attitudes and perversions as well as indirect means of social control.

Closely related to dominance is the phenomenon of territorialism, which has been described for representatives of most classes of vertebrates. A limited geographical area is settled upon and defended by an animal, usually a male, and is used by him for mating and rearing of a family. While a description of territorialism as observed in natural habitats is outside the scope of this paper, its importance must not be overlooked, since those factors which determine dominance status probably also influence the relative amount of territory acquired by an individual. In strongly territorial species little dominance fighting is observed, once territory is established, but when conflict does occur resident animals usually have a decided advantage over invaders. In testing for dominance status, with some species at least, psychological factors of familiarity with the environment may influence the results profoundly, since the "home cage effect" has already been clearly demonstrated. Territorialism in birds has been studied in some detail by field observers (**51**, **52**, **64**, **73**, **91**). Carpenter (**115**) found interesting territorial relationships between clans of howler monkeys observed in their natural habitat, while dominance behavior within the clan seemed to be lacking.

Reptiles. The comprehensive paper of Noble and Bradley (**28**) serves as an introduction to the work with lizards, since a summary of earlier studies on dominance, territorialism, sex recognition, and mating behavior is given. These authors observed 12 representative species in the laboratory and found that fighting occurred in all genera save *Amieva,* which is known to be gregarious in the wild, in contrast to the territorialism of individuals of other genera.

Typically, when 2 males meet, a display takes place in which each erects its dewlap or crest to its maximum extent, as he walks sideways toward his opponent, flattening his body in the vertical plane. Bobbing up and down rhythmically increases the visibility of the colored sides and under-surfaces of those males which possess such sex dimorphism. Often, bluffing is effective in driving away a rival, particularly in highly colored males, although when one male does not give way actual fighting with the teeth results. Fighting among

males, which leads to the acquisition of territory in the wild, occurs during the breeding season.

Evans (22) employed a method specially adapted for lizards to work out a hierarchy among a group of *Anolis carolinensis.* Among a group of caged lizards only 1 animal appeared dominant, while all the others were subordinate and showed no differentiation among themselves. Evans placed 19 adult males in one cage, and, as soon as one had asserted dominance through fighting or bluffing all comers, turning the characteristic bright green color, he was caught, weighed, marked, and transferred to a second cage. As soon as another asserted dominance, he was transferred to cage 2. The first male to become dominant in cage 2 was moved on to cage 3, and so on until 6 cages had been used. As Evans seems to agree, the experimental determination of a hierarchy in lizards necessarily yields a result which, from the point of view of natural conditions, is an artifact. By arranging the animals in 4 groups, in accordance with the extent to which they maintained, in successive cages, the order of dominance assertion shown in the first cage, a fairly straight-line relationship was found between averages for these 4 groups and weight. Ninety of the 98 decisive combats occurring between a dominant animal, already resident in a cage more than 24 hours, and an invader were won by the resident. Yet in 38 of these 98 encounters the lighter animal won. Evans took these victories over heavier animals to indicate the marked effect of the "territorial urge" (p. 108). Kramer's study (26) of 4 male and 3 female green wall lizards *(Lacerta milisellensis)* confirmed many of the points of Evans' work.

Evans also explored the hormonal control of fighting in lizards (20, 21, 23, 24). He injected a group of males with Antuitrin S and another with sheep pituitary extract, both of which resulted in fighting and courting by males outside the breeding period. In another experiment castration of females was found to liberate fighting behavior. This work is significant as indicative of a relation, even in the lizard, between sex and dominance behavior. In a Cuban field study (25) Evans explored the relation between behavior manifestations of dominance and territorialism. He was able to map the territories of 47 individual males and 8 individual females by placing a test specimen somewhere within the area and observing attack by the resident. Territories averaged some 400 square feet and usually contained an elevated "lookout post."

Birds. Schjelderup-Ebbe is the most prolific as well as the first writer on dominance in any animal. His first scientific report

appeared in German in 1922, although unspecific reference is made (**88**, p. 952) to a paper published in Norway in 1913. The 1922 paper (**78**), which has been extensively reviewed in many places, was concerned entirely with the domestic chicken, while later papers (**79–87**) describe observations on upwards of 60 representative species of Carinatae, or keel-bearing birds, including many common European land and water forms and some tropical species. He says that, in general, the phenomena of dominance are the same in all the birds studied, the chief differences lying in the variations in intensity of fighting and consequent importance of ranking as a determinant of social interaction. The author gives much more attention to general descriptions of his findings than to accounts of observational methodology and behavioral details, so that it is often difficult to evaluate his general summary statements. Papers after 1922 are disappointingly repetitious, in so far as they concern dominance. An English summary of his work was prepared by the author (**88**), and other summaries have been given by Katz (**53**, **169**).

Schjelderup-Ebbe's original observations on *Gallus domesticus* employed large groups containing 25 to 150 individuals, and small ones ranging from 2 to 25 members. The pecking of one chick by another was used as the index of dominance status, observation of which revealed regular "peck-orders" among all groups, sometimes linear but more often polygonal. The "peck right" was found to be unilateral, *i.e.* in 1900 observed instances of pecking, if animal A once succeeded in worsting B, B thereafter was never observed to peck A, except on the rare occasion of a general revolt against the despot.

Dominance behavior appeared between the 20th and 30th day after hatching. Rank was roughly related to age and strength, and was maintained, once established, with little combat until senile changes during the 5th year altered the appearance of an animal, whereupon it was attacked as a stranger by other members of the group. The severity of dominance behavior was inversely related to rank; the despot over many pecked less often and less severely than one farther down the hierarchy. Removal of birds dominant over such an individual resulted in diminishing the severity of his treatment of his subordinates.

According to Schjelderup-Ebbe (**82**), factors influencing dominance include: (1) relative size, strength, and age; (2) circumstantial or attitudinal conditions attending the first meeting of 2 birds; (3) sex (in the relation between cock and hen, in which the

cock is known to grant privilege during the mating season to his hen); (4) health; (5) familiarity with surroundings; and (6) the development of special friendships which cut across dominance lines.

To check Schjelderup-Ebbe's work under more precisely defined conditions, Masure and Allee studied the domestic chicken and pigeon (**31**, **57**) and also the shell parrakeet (**58**). Two groups of 11 male and 26 female (later reduced to 13) brown leghorn chickens were observed at feeding time in enclosed yards for 70 and 60 days, respectively, beginning in the 10th month after hatching. A linear dominance hierarchy appeared in the pullets before observations ended, but triangular relations persisted among the males. Much more fighting took place among males than among females. The chief result of some 30 days' observation of 7 male and 7 female white king pigeons, in separate groups, was the discovery of a "peck dominance" rather than a "peck right," as claimed for all birds by Schjelderup-Ebbe. In the former, no one of a pair of birds wins all the contacts, but only a majority, while in the latter the dominant animal is never pecked by the subordinate. When the sexes were paired, mating took place between most individuals and the whole group was dominated by 2 aggressive, unmated females.

The shell parrakeets, which live in flocks of some 1000 individuals each in their native Australia, were observed in 2 groups of 8 birds each, 4 of each sex, and 1 group of 14, equally divided as to sex. Again, no absolute peck right was discovered; a record of contacts showed that no one animal won all its contacts nor did any lose all. When the like-sexed flocks were mixed, all the females dominated all the males.

From their observations, Masure and Allee agreed with Schjelderup-Ebbe's description of fairly straight-line hierarchies and absolute peck right in *Gallus domesticus*, but failed to confirm his assignment of clear, linear dominance to pigeons or shell parrakeets, although these authors were not sure that hierarchies might not have appeared in these latter species with a longer period of observation. They also found that the top-ranking birds were the most aggressive; in one group of chickens half the pecking was done by the dominant animal—again in contrast to Schjelderup-Ebbe.

In an ambitious attempt to formulate social law, Murchison (**66**, **67**, **68**) set out to relate dominance as measured by direct observations of pecking in *Gallus domesticus* with 3 other tests of social behavior: (1) the relative distances 2 animals would move toward one another in a narrow runway; (2) the frequency of treading

pullets by a cock; and (3) the differential approach of a chicken to 1 of 2 "stimulus animals" in a discrimination setup. Although as many as 18 subjects were used in part of this work, most of the results were obtained with 6 cocks and 5 pullets. The straight-line relationships obtained between various measures can be accepted only very tentatively, since they were based on 6 and often on only 4 or 3 points. The data, therefore, do not justify the extensive mathematical treatment (**70**) given them by the author. The results tended to show that the animal who won fights from the greatest number of others also moved further and faster in the runway toward any other animal in the group, and that the dominant cock did most of the treading of the pullets. In choosing between 2 males, a male usually approached the less dominant one, while a female would approach the more dominant of 2 cocks. Measurements were made with each test from the 1st through the 36th week.

In subsequent papers (**69, 72**), the above behavioral measures were reported to be related to loss of body weight during 48-hour starvation, but not to any of the morphological characteristics determined by post-mortem examination. Using new groups of subjects, Murchison (**71**) found that the elapsed time before the formation of a linear hierarchy varied as a function of the size of the groups.

In connection with a study of the sex behavior of chickens, Skard (**90**) obtained a correlation of +0.54 between the frequency of treading by 1 cock of 10 hens and the peck order of the hens. In another group the correlation was +0.24. Miya's (**65**) report on observations of 3 groups of chickens substantiates the descriptions of dominance in these birds already presented. In addition, this author found an increase in the tendency of 2 strange chickens to fight when members of each contestant's group were present. Katz and Toll (**54**) found some relation between relative dominance status and performance in a simple learning test.

In their study of social behavior of the black-crowned night heron, Noble, Wurm, and Schmidt (**75**) used a unique index of dominance status. When a pair of birds performed the "billing ceremony," the one which held its head highest was considered dominant. This, they explained, is a habit perseverating from the time when young animals in the nest competed for food brought by the parents by stretching their necks upward. Strong territorial habits of even the immature birds of this species prevented the use of pecking or performance in Murchison's runway as criteria of dominance.

Glass cages, smaller than territories normally occupied by pairs

of young birds, were arranged, and groups of 8, 7, and 7 subjects, drawn from 15 individuals, were placed 3 at a time in each cage, and the billing was observed from 2 to 10 days, or long enough to obtain a reliable result. From 0 to 147 billings occurred during a day. The results showed a linear hierarchy in all but one of the groups, where 1 triangle appeared. Birds which were tested in more than one group occupied the same relative positions with respect to each other in every group, although in one group they all ranked at the top and in another at the bottom of the hierarchy. The test behavior of pairs of birds who had lived together on territories was not distinguishable from that of those pairs which had experienced no mutual contact save in occasional defense of territory. Concerning territorialism and dominance, the authors stated that the peck order in herons "regulated the formation of pairs but seems to be of little practical value in the social life of captive herons once the territory drive has isolated pairs of young birds" (p. 22). These authors found, in supplementary experiments with pigeons, that birds accustomed to a cage invariably won fights against invaders.

Mammals. Most of the studies on mammals offer only fragmentary data. In a preliminary note Schjelderup-Ebbe (**105**) stated that he made observations on a variety of domestic and caged mammals in which dominance was observed in various degrees of clarity. Unfortunately, a full report of this work seems never to have appeared. Davis (**98**) presented a 7-point rating scale for measuring "aggressiveness" of a rat against its fellows (in contrast to aggressiveness against the observer's hand, etc.); the same measuring instrument might be used in a study of dominance. James (**100**) employed 5 dogs to study the effect of the presence of one dog upon the conditioning of another, and found that CR formation was inhibited in the subordinate dogs, although the results may have been due to direct interference by the dominant dog at the food delivery apparatus. James observed that dominance in the living cages was expressed by (1) fighting, (2) taking food from another dog, (3) usurping choice resting places in the kennel, and (4) driving away another dog in order to receive attention from a human being.

Winslow (**110**) described the type of dominance he saw among laboratory cats in a group of unreported size. Despotism of a single animal and undifferentiated subordination characterized the group relationship. The dominant animal mounted all others in a copulatory fashion regardless of their sex. When the despot was removed,

"communism reigned" for a few days and then the next most aggressive male emerged as despot.

By far the most satisfactory study on mammals, other than primates, was made by Uhrich on white mice (**106**). Some 300 males and 150 females, in a total of 85 groups, were observed in their living cages from 2 to 6 hours daily for continuous periods ranging from 3 to 268 days. Groups contained from 3 to 9 individuals. Fighting was used as the sole criterion of dominance, and data were recorded in terms of the predominant type of fighting observed on each day. The groups were classified into 4 somewhat overlapping categories for those showing (1) exclusive dominance, (2) a variety of types of fighting order, (3) linear dominance, and (4) no established order. Exclusive dominance of a group by a single animal, while the other members remained undifferentiated, was most frequently observed. Resistance to the dominant animal occurred occasionally and was considered a transitional stage, as were, also, cases of apparently equal dominance. A hierarchical arrangement of 2 or 3 animals was sometimes observed among the larger groups, but the linear order never extended further.

The temporal duration of a dominance order of any type was extremely variable, and changes took place gradually, abruptly, or with an interval of quiet in which no dominance was apparent. In most cases the inciting cause of change in order was not observed, while a few followed artificial types of interference with members of the group. Dominance status was found unrelated to weight, but some indication was obtained for a positive relation with age. When a new animal was placed in a group, the dominant animal usually attacked it. In living cages provided with a feeding device at which only 1 animal could eat at a time, no consistent order of feeding or striking inequalities of food obtained by dominant and subordinate mice could be detected. Evidence was obtained for a "home cage effect" in the augmentation of fighting ability of individuals against nonresidents or those removed from the company of familiar cagemates.

In addition to the above, 18 pairs of males were observed for an average of 53 days (range 13–105), during which complete dominance by 1 animal was found on 42% of the days, no fighting was noted on 48%, and the remaining 10% was classified as unknown or changeable order. In commenting upon all of his data Uhrich warned that caution must be exercised in generalizing on types of

social behavior found when only a few groups of any species are studied. He concluded that the "social level of organization" is obviously much lower in mice than in many mammals and birds, and that mice do not always "know" who is dominant in their group.

Primates. The obvious relation between dominance and sex behavior adds to the complexity of the manifestations of dominance among the primates. The early observations of Hamilton (126) and of Kempf (129) on macaques and baboons suggested that sex behavior served functions other than reproduction. Strangely enough, Rêvész (139) failed to report observations of sex behavior when he tested for dominance in monkeys of various sorts. He vividly described the cowering of subordinate monkeys, as soon as a bit of fruit was held in front of the cage, regardless of whether the despot of the group threatened them at the moment or not. Incidentally, a peculiar place of privilege was granted the youngest and smallest monkey of the group; he was able to sit by the despot at the front of the cage and take food from the experimenter. Rêvész explained that the youngster had not yet begun to fight and hence had not learned to become frightened.

Zuckerman (155) obtained his original data from observations on baboon colonies in their native South Africa, on groups of some 100 individuals maintained on "monkey hills" in the London and Munich Zoological Parks, and on baboons and other primates caged in various groupings. He described how the dominance of the male overlords controlled all social interaction in the baboon groups, including the obtaining of food or any desirable object or attention, the handing down of punishment from more to less dominant animals, and the occasional rendering of assistance to a subordinate against an attacker. In a very large proportion of the cases dominance was clearly manifested by sexual behavior; the subordinate animal characteristically presented to the aggressor of either sex. Zuckerman argued that since "both the male and the female primate are always to some degree in a sexually receptive condition" (p. 238), and since various reproductively inadequate stimuli are effective in evoking sexual behavior, sexual responses must have become conditioned to fear-producing stimuli, and presentation may therefore be regarded as an incipient flight response. This hypothesis must be examined for each type of primate in the light of what is known about periodicity of receptivity in the female. Its application to the male implies some sort of imitation of the females by the males, a type of primate behavior which is popularly regarded as very preva-

lent, but actually difficult to demonstrate in any large portion of experimental cases.

Maslow made a series of observations on a variety of monkeys from which he was able to describe a " behavior syndrome of dominance." The first paper (133) reports observations on 35 Old- and New-World monkeys and baboons which were caged in groups of 2, 3, and 4 animals. Qualitative records were kept of significant behavior appearing when food was introduced into the cages. In a second paper with Flanzbaum (136), a systematic test method was employed with 23 monkeys (mostly macaques), which were kept in isolation save when they were paired for daily test sessions. This same methodology was subsequently employed (135) with 6 rhesus monkeys, which were tested in every possible pairing. Food was placed in the reaction chamber at regular intervals during each test period, and records were made on check lists of amount of food obtained by each subject and the frequency of various types of behavior displayed by each.

Results from both these experiments showed that in general the animal which obtained the most food also did most of the sexual mounting and bullying (plucking fur, biting, threatening with growls, mauling, etc.), and initiated most of the fighting, while it was never observed to cringe, was rarely passive under aggression, and almost never took flight from its partner. Frequency of grooming, sexual presentation, and play behavior did not consistently differentiate members of the pairs. The numerical scores presented for these items are mutually incomparable because they were calculated in different manners and were based on varying numbers of cases. Food division was the only uniform test applied to all animals, the other observed behavior occurring spontaneously and irregularly. The difficulty of quantitative description encountered here is typical of that met whenever the attempt is made to subject personality traits to measurement.

Maslow found that the behavior of most pairs in the test situation became consistent before the 4th period, often before any fighting occurred, which suggested to the author that relative dominance status may be represented by attitudes, gestures, or other nonscorable behavior, which another animal may recognize at once and react to accordingly. On the other hand, the lack of perfect correlation between obtained scores led the author to suggest that there may be specific types of dominance (food-, sex-, and aggression-dominance, etc.) rather than a general dominance. In comparing this work with that reviewed for other vertebrates it should be noted that Maslow

did not use the outcome of fighting as the primary index of dominance.

After a hierarchy had been worked out with the results of all pairings of the 6 animals employed in the last study (135), a larger group was formed by placing the animals together in inverse hierarchical order. It was found that concerted (not necessarily coöperative) attacks on higher ranking animals by subordinates upset the calculated hierarchy. Finally, Maslow offered a theory of dominance (134) in which he attempted to account for most nonreproductive sex behavior as a function of a dominance drive; but at the same time he appears to have regarded this as sex behavior differing in kind from that employed for reproduction, thus becoming involved in the logical difficulty of trying to prove, from the same original data, the existence of both a new type of behavior and a new drive.

Family Life

Within the family group development of the social responsiveness of young animals, as well as patterns of maternal care and control of infants, may be observed. While naturalistic observations have been made in this area on a variety of vertebrates, the field has been left almost untouched by experimental methodology. Most of the controlled laboratory observations have been made with chief interest in the unfolding of innate behavior patterns in the mother rather than in the genesis of social responsiveness in the infants (109).

Fish. Two observational and experimental studies have been made on family groups by German authors, whose interest lay in tracing the transition from what Deegener (164) called the *Gynopaedium* and *Pateropaedium,* or mother- and father-families, to the *Sympaedium,* or aggregation of independent young. Schulz (12) observed in the laboratory some 50 broods of sticklebacks, one of the unique types of fish in which the father guards the nest and cares for the young. Tests were made which showed that the father's behavior was not greatly altered by the introduction of young from other nests or by reduction of the number of young in his own nest. Of particular interest is his observation that when the young became mature enough to emerge from the nest the father swam about with them as a member of the school, but not in any sense its leader.

Birds. Brückner's extensive study (37) on the breakup of mother-families in domestic chickens was made on 36 groups of hens with chicks or incubator-hatched chicks. Three stages in the life of

the mother-family were distinguished: (1) concentration phase, lasting from hatching until the 2nd or 3rd day and characterized by very close association between hen and chicks; (2) fluctuating contact phase, lasting until the 10th or 12th day and characterized by short excursions of chicks from the hen, and clucking apparently directed toward specific, straying chicks; and (3) the dispersion stage, lasting from the 12th day through the 6th or 8th week and characterized by a much greater freedom of the chicks but continued response to the hen's clucking. Breakup of the families took place rather quickly. The hen ceased clucking, pecked at the chicks when they approached her, and finally began to lay again and would no longer tolerate members of her brood.

Brückner concluded from experiments in which the visual appearances of hens were altered that chicks recognized their mothers by both visual and auditory stimuli. Chicks of 2 families were mixed in the dark and were found grouped under their own hens within 2 hours. The author found evidence that hens recognized chicks as belonging to their own brood, but not as individuals. Among chicks, individual recognition was first evident when fighting and the process of rank-ordering began at about the 14th day and continued without serious interference from the hen. On breaking up of the family the chicks remained in a group, or *Sympaedium*, for some time, even though immersed in a larger group of adults in the henyard. The hen, on leaving her chicks, joined the adult group if such was present; otherwise, she remained with her chicks and defended her position in the peck-order as long as she was able. Studies of the adoption of strange chicks into the mother-group were made in which success seemed to depend on similarity in appearance and behavior of the newcomer to the brood. A type of coöperative behavior was sometimes shown by 2 hens who reared their broods together. Brückner found no evidence for tuitional behavior by the hen.

Primates. Of the naturalistic observations, those made on primate mother-infant groups may be singled out (**113**, **118**, **131**, **142**, **149**), since the relatively long period of infant dependence and the strong social responsiveness of these vertebrates will doubtless provoke systematic and experimental study in the near future. Yerkes and Tomilin (**152**) amassed considerable data on 5 mother-infant groups of chimpanzees and found as many varieties of maternal treatment and infant response. Some description of the early development of social behavior between chimpanzee twins was given by the same authors (**143**).

Effect of Isolation on Social Behavior

By the early isolation of young animals the effect of deprivation of parental care and companionship on subsequent social behavior may be studied.

Birds. Craig (42) began this work by rearing 3 male doves in isolation for periods of from 1 to 3 years and studying their initial responses to females. Two of the 3 made sexual responses to the experimenter's hand which fed them; all showed maladaptation to mating behavior when paired with a female, but after some practice they became proficient. The symbolic function of the experimenter's hand as a stimulus for all sorts of social and sexual behavior is perhaps the most interesting result of this study.

Brückner (37) reared 2 domestic chicks in small wooden boxes in a brooder. The chicks could see shadows of other chicks through translucent windows of the boxes and could hear them. When alone, they developed various types of play and tossed worms and other foods about as if other chicks were present and competing for them. On pairing each isolated chick with another chick at 7 weeks fighting occurred, as well as pecking at a mirror image of itself. On being released into a group of 250 chicks the isolated chicks showed bewilderment and retreated to secluded nesting places as soon as possible, to avoid pecking by the others.

Two experimental studies have recently appeared in which the effect of early isolation on social responsiveness was subjected to measurement. Pattie (76) arranged an experimental pen with 2 stimulus compartments, one containing 2 chicks and the other, 2 white mice. Beginning with the 4th day of life, 42 isolated chicks and 42 normals were placed one at a time, daily, for 30-minute periods, in the test pen, and the time spent in front of each stimulus compartment was automatically recorded. Social preferences measured in this way over the whole 6 days showed no significant difference between isolated and controls, but, when the first 3 days were considered, a preference of the isolated chicks for other chicks was shown, which waned in favor of a preference for mice on the last 3 days.

Mammals. Bayroff (94) separated the members of 6 litters of rats from their mothers at 19 days and reared half in isolation and half together. Subjects were selected for experimental and control groups by being paired for activity, one being placed in isolation and the other in the social group, 47 subjects being used in all. After

a preliminary training period, begun on the 115th day, all animals were given 60 daily opportunities to choose between compartments containing 2 other rats and food, and only food. A second experimental series employed only stimulus animals *vs.* an empty compartment. No consistent differences between the social preferences of rats reared in isolation or in groups were found. Perhaps the rather disappointing results of such careful experimental work on this topic come from an overeagerness for quantification to the neglect of systematic qualitative observation which might indicate striking peculiarities in interactive behavior of socially naïve subjects.

Primates. Infant primates have been reared in isolation for the chief purpose of observing maturation of innate behavior patterns and study of infant mentality under controlled conditions. Jacobsen, Jacobsen, and Yoshioka (**128**) reared a chimpanzee from birth to 9 months, and described the first responses of the infant to another infant at the end of isolation. Aggression by the young ape was replaced by dependence on her own companion after a few weeks. Foley (**124, 125**) reared a male rhesus monkey in isolation for 2 years and reported on responses to a mirror and to other animals occasionally presented during the isolation period. No detailed account of the initial adaptation to life with other monkeys after the isolation period was given, beyond a general statement about genital exploration and preference for females by the experimental male.

Communication

The term *communication* lacks precise definition in its application to animal behavior, for it may be stretched to include almost any sort of anticipatory movement which may signalize an activity to another individual, or it may be limited strictly to vocalizations or gestures which clearly direct or predicate. While communicating in some sense is obvious in at least many birds and mammals, the possession of a "true" language by any animal has long been a subject of controversy. Bierens de Haan has written extensively (**35, 161, 162, 163**) on this question, reviewing the literature on animal communication through 1934. He argues that animals do not possess a human type of language, because no reported instance of animal communication has shown all the characteristics which he believes distinguish the elements of human language (vocal, articulate, indicative, conventionalized, intentional, and capable of regrouping to give new meaning). This author finds that some of these characteristics

are displayed in a few instances by some animals, but they are never all present at once. Groos (**168**) presents arguments of the same nature.

While there have been numerous descriptions of the calls of animals made in their natural habitat, the objective recording of these and the careful description of the conditions under which they occur have not often been made (**33**). Perhaps the available information (**40, 49, 50**) may best be summarized by saying that the calls, especially of birds, have in some cases been found to fit into regular patterns of recurrent behavior and probably serve as signals to release, in Lorenz's (**55, 56**) terminology *(vide infra)*, or to inhibit the reciprocal behavior on the part of other individuals. The more or less stereotyped behavior immediately preceding flight, copulation, etc. has been regarded as an effective means of communication among birds (**43**).

The natural modes of primate communication and the attempt to elicit vocal response for problem solution have been adequately treated by Yerkes and his associates in various places (**151, 153, 154**). Taking the suggestion of Bloomfield, amplified by Esper (**166**), that the "fundamental linguistic situation" is that of coöperative action involving 2 or more individuals, Crawford (**119, 120**) observed gestures used by chimpanzees in coöperative problem-solving, and found that, in some instances, they showed an element of directiveness, or predication.

Related to the subject of communication in animals are studies of sound mimicry by birds (**39, 77, 89**) and the native or acquired nature of call and song. Schjelderup-Ebbe's work (**81**) remains the only extensive study in this field where large enough groups are employed for statistical reliability. After carefully describing 13 types of vocalization in chickens he experimented with 360 incubator-hatched chicks in 6 groups. The groups were reared in varying degrees of visual and auditory isolation from adults. It was found that crowing by young males was the only vocalization which appeared earlier in chicks within sight and sound of adults than in isolated groups. The most objective work in this field is being carried out by Metfessel and his co-workers on the canary (**30, 38, 59, 60, 61, 62, 63**).

Also related to the topic of communication are the attempts to teach animals to use human words (**101**; other studies reviewed in **153, 161**). The most recent work on the reactions of vertebrates (dogs) to verbal commands was done by Warden and Warner (**107**)

and Sarris (**104**). The former's critical examination of the famous dog, "Fellow," revealed considerable ability of the animal to follow commands. Sarris' extensive work on 3 dogs, in which the ability of each animal to use verbal cues in diverse types of problem solution was studied, suffered from lack of complete control of possible visual cues and often from an inadequate number of trials in various problem situations.

Special Categories of Social Response

Response of the Group to an Individual. A few investigations on birds and primates have been found which offer suggestive beginnings toward definition, description, and analysis of the concept of a social group. Work in this highly significant area should be pushed ahead with animal subjects, where composition of groups and stimulus conditions are subject to experimental control.

(1) *Birds.* Fischel (**45**) observed 500 domestic hens in a large open yard and found that they almost always moved and fed in groups. Direction of movement of the groups seemed to be defined by the features of the terrain and the wanderings of "leaders" who moved at the apex of each group. A number of animals seemed to race for this position of *Spitzentiere,* and, while the same individual did not always gain the place, it was usually held by one of a limited number of hens. Dependence of this leader on the group was indicated in the way she would wait for others to catch up if she moved more than a little distance away from them. Leadership and position in the dominance hierarchy did not seem to be related. It is doubtful whether *Spitzentieren* may be called real leaders, since one hen was not always leader, nor was it observed that her example was followed in anything other than locomotion.

A very suggestive type of work was begun by Schjelderup-Ebbe (**81**) on the recognition by group members of individuals belonging to the group. He altered the appearance of hen's heads by covering the comb with a bonnet, or by coloring comb and head feathers with various dyes. In most cases the transformed member of the group was treated as a stranger and was forced to work her way into the closed dominance hierarchy through fighting. Alteration of appearance through sickness and old age likewise resulted in aggressive treatment from the group. Suggestive techniques for this type of study were employed by Noble and Vogt (**74**) in their experimentation on sex-recognition in the red-winged blackbird and the northern yellowthroat. They used stuffed birds mounted in

various positions and altered in different ways. Noble, Wurm, and Schmidt (**75**) studied individual recognition of 6 young black-crowned night herons when the appearance of individuals was altered and also when auditory sensitivity was eliminated. Observations on the recognition of offspring by parents should also be mentioned here [Heinroth (**48**), Whitman (**92**), Schjelderup-Ebbe (**81**, **83**), and Brückner (**37**)].

A very interesting theory bearing on the topic of group relationships has been offered by Lorenz (**55**, **56**). It is well known that birds of different groups or species make immediate, appropriate, and stereotyped responses to particular kinds of objects or individuals, especially those belonging to the group or species. Lorenz postulates that certain characteristics of coloration or plumage prominently displayed by birds during certain behavior serve as specific "releasers" for the stereotyped recognition behavior. This coördination of movement and response between birds may serve as a "private signaling code" for a group or species. Preparatory activities and feather displays made by birds before taking flight are the clearest examples of releasers. The connection between releasers as stimuli and the appropriate response is made early in life through the process of "imprinting," which Lorenz hesitates to classify as learning because it takes place during infancy, long before the response itself appears. Because of the completeness and irreversibility of the imprinting, Lorenz suggests an analogy to the "induction" of growth of transplanted tissue described in experimental embryology (Speman). Imprinting at once fixes the organism within the social group of whatever parents may rear it. The social relationships that will exist in later life will be strictly limited to the behavior which is thus released. For this restricted type of companionship, which may exist between individuals, Lorenz borrows Von Uexküll's term of *Kumpan,* which is not strictly translatable into English, but refers to a companion for a limited activity, as a hunting-companion or drinking-companion. Among birds, Lorenz discusses the characteristics of releasing functions for parent-companion, child-companion, sex-companion, social-companion, and brother-and-sister-companion.

(2) *Primates.* Using 5 baboons as subjects, Dolin and Palatnik (**122**) studied the response of a group to an individual's behavior in a learning experiment. The animals first learned to approach a food container at the sound of a bell, which required from 21 to 300 trials. Next, a lever was made available which could be operated by an animal to ring the bell. The conditioning of members

of the group to the approaching and manipulation of the lever by a single animal was followed, and it was found that individuals learned to respond to their fellows' movements in from 2 to 231 trials. The authors seemed more interested in the learning aspects of the problem than the social relations involved. Of course, the apparent response to the individual may have been simply an anticipatory response to the bell.

The possibility of the formation of a "taboo" by a group of rhesus monkeys against a single individual who was the instrument of their punishment has been reported in abstract by Child (**117**). Each animal was free to mount a platform to obtain a piece of banana, which resulted in the floor of the cage being momentarily lowered a half-inch into hot water, so that the other animals present in the cage were punished. Another platform was available from which a piece of carrot could be reached without resulting in punishment for the group. "Inhibition of the tendency to take banana appeared rapidly and persisted in each animal, the principal source apparently being undirected commotion of the other animals" (p. 705). While this attempt to build up a "taboo" in monkeys proved inconclusive, the methodology is extremely suggestive. If it could be shown that animals can exert a definite pressure against their fellows because of antisocial behavior, a way would be opened up for the experimental study of many baffling human problems.

Grooming Among Primates. Students of primate behavior have unanimously recognized grooming of one animal by another as an important pattern of social interaction. The term has been used to designate visual examination and picking through another animal's hair, in which objects discovered are usually transferred to the mouth of the groomer. Watson (**145**) early described it in the monkey, and Köhler (**130**, pp. 320–323) gave an accurate account of its typical form in chimpanzees. Zuckerman (**155**) made frequent reference to grooming among baboons, particularly that done on the person of the overlord by females in his harem who happened to be in the receptive phase of their sex cycles. Zuckerman maintained that the grooming response is evolved from a fundamental attraction which fur of any kind has for monkeys and baboons.

Tinklepaugh (**141**) concluded from observations on a pair of well-acquainted macaques that the male attempted not only to keep the female's hair clean, but also to alter her appearance to suit his taste by hair-plucking. Concerning the innateness of the grooming response, the Jacobsens and Yoshioka (**128**) reported its sudden

appearance during the 39th week in a chimpanzee raised from birth in isolation, while Foley (**124, 125**) never observed it in a rhesus monkey similarly raised for the first 2 years. As noted above, Maslow (**135**) could find no relation between frequency of grooming and dominance status. Ewing's (**123**) discovery of the fondness of a monkey for salt crystals, experimentally placed on his skin, led him to conclude that auto- and social grooming are done in search of materials having a salty taste from sweat. Such an explanation hardly seems satisfactory for grooming among animals to whom salt is always available in rock form in their living cages.

Yerkes (**147**) summarized the evidence for the importance of grooming as a means of social interaction, and maintained that from it may "have evolved varied and highly significant kinds of social service" (p. 12). He recognized a functional identity between grooming in infrahuman primates and "delousing" in man. From his own observations Yerkes stated that grooming does not appear in chimpanzees until after the 3rd year, that it seems to be its own reward, apparently indicates friendliness, and is essentially a mutual activity which may represent a purely altruistic form of social service. As pointed out by this authority, much careful genetic and experimental work should be done to discover the importance of this behavior.

Food-Sharing and Coöperation in Chimpanzees. With the chimpanzee, a beginning has been made on the study of social interaction patterns resulting in the combination of resources or mutuality of effort. Köhler (**130**) observed food-sharing between 2 chimpanzees and vividly described the begging done by the ape desiring food (pp. 312–313). Begging other apes or human beings for all sorts of things or attentions has been noted by observers of orangoutang, chimpanzee, and gorilla (**132, 153**).

Following observations of Wolfe (**146**) on the sharing of food-tokens by pairs of chimpanzees, Nissen and Crawford (**138**) arranged a situation for the study of food-sharing between 6 immature chimpanzees in 8 different pairings. Members of pairs were placed in adjacent cages connected by a grille partition through which an animal might reach, and food was given only to an animal in one cage. The other chimpanzee obtained some of it by reaching directly for it, by begging the partner for it, or through what appeared to be unsolicited passing by the partner having access to the food. The successful begging and unsolicited passing were found only with well-

acquainted and friendly pairs; certain animals, however, begged vigorously in any pairing. The begging was done with arm outstretched, palm up, wrist moving up and down, and occasionally was accompanied by whimpering and foot-stamping. Discovery of motivation for food-sharing and conditions of its elicitation will not be revealed until chimpanzees of all ages are studied.

Opportunities for coöperation or teamwork by a pair of chimpanzees were offered in the tests on box stacking of Köhler (**130**, pp. 166–172) and Bingham (**114**, pp. 76–77), but mutual obstruction and independent activity characterized the behavior during the limited periods of observation. Carpenter (**116**) reported that he saw 2 gorillas, under observation in a zoological park, coöperate in moving a log, although he gave no details of the behavior. Crawford (**119**) employed various problem situations to study coöperation in animals formerly trained to do a similar task alone. In the situation yielding the clearest results, 2 animals were required to pull in with ropes a box too heavy for a single ape to move, in order to obtain pieces of fruit. Active tuition and assistance by the experimenter resulted in the first stage of coöperative behavior characterized by independent pulling on a rope in response to verbal command. Two other stages developed spontaneously. The second was characterized by watching the partner and response to its pulling; the third was distinguished by gestural solicitation of the partner's pulling. Of the 5 subjects employed all reached stage 1, in certain combinations all showed behavior typical of stage 2, and 2 solicited in the manner characterizing stage 3. It was argued that the solicitation here displayed had only a signalizing, and not a directive, significance for the partner.

Another experimental situation was arranged (**120**) which required pairs of animals to operate 4 devices in serial order to obtain food from a vender. After 3 subjects were trained alone in the serial habit (which required responses to color stimuli independent of location) they were paired with other apes who had learned how to manipulate individual devices but were unfamiliar with their serial order. During delays the trained animal was observed making gestures toward the partner, which resembled the solicitation previously observed, but which had an added element of directiveness, since the solicitor seemed to push, beckon, or draw its partner toward a particular one of 2 devices. The solicitation of the dominant animal, here as elsewhere, seemed to be of a commanding type, while that of the subordinate connoted suppliance.

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SOME PSYCHOPHYSIOLOGICAL RELATIONS[1]

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The present review is an attempt to summarize the experimental literature dealing with the changes in mental performance and function which follow alterations in the internal environment. The well-known phrase of Claude Bernard, "The constancy of the internal milieu is the condition of the free life," may well serve as a guiding text. It is apparent that the relationship between mental and physiological functions may be considered in either of two directions: first, how may physiological functions be altered by mental processes; and second, in what way will alterations in the physiological environment affect mental performance? In the present review we shall be concerned only with the latter relationships.

Changes of Oxygen Tension

The effects of lowered availability of oxygen may be considered under immediate short-term effects or under the effects of long-continued oxygen lack in which a period of acclimatization may occur.

Short-Term Immediate Effects

The problem of the immediate effects of low oxygen content of the inspired air has important practical applications in the field of aviation, and it is in connection with the selection of aviators that the first experimental work was carried out. These early experiments have been summarized in detail by McFarland (69). However, the experimental conditions in these early experiments were such that little impairment in mental function was found prior to physiological collapse. In these experiments the anoxemia was built up over a relatively short interval of time by rebreathing expired air from which the carbon dioxide was removed, so that conditions of physiological equilibrium were not attained. Furthermore, the subjects were highly motivated, and the tests were directed primarily

[1] Grateful acknowledgment for clerical assistance in the preparation of this report is made to the Works Progress Administration (O.P. 665–08–3–30, Unit A–8).

toward specific psychological functions in which practice effects could be minimized. McFarland found that choice reactions were impaired when the oxygen in inspired air fell to about 11% and gradually became worse with increased deprivation. After exposure of an hour or more, the effect of lowered oxygen was greatly accentuated. Simple sensory and motor responses were not seriously impaired until the subject approached collapse from oxygen want. Touch and vision were apparently the first sense modalities to be adversely affected and audition, the last. In these experiments the higher mental processes, with lack of memory and attention, were impaired first at relatively low oxygen deficits, although awareness of what was going on persisted until collapse. Irrational or fixed ideas were frequent, and capacity for sane judgment and self-criticism was lost. As in other experiments (**5**, **6**), the subject was reported to be frequently unaware of the profoundly altered behavior and often insisted on continuing the experiment in spite of obvious dangers. Barach (**3**) is of the opinion that, after even slight oxygen deprivation, grave errors of judgment may be made and attributes certain aeronautical accidents to this cause. Perseveration, both with respect to ideas and motor responses, was frequently reported.

Goralewski (**42**) studied the effects of anoxia, using a rebreathing apparatus which removed the carbon dioxide from the expired air but with a gradually decreasing oxygen supply. He used handwriting which had previously been found to suffer marked impairment under lowered oxygen tension (**69**). By making a rough comparison of handwriting specimens obtained under normal and anoxic conditions, the author stated that, in a group of 100 subjects, approximately 44% showed definite disturbances when the oxygen content of inspired air was between 14 and 18%; 22% of this group showed the first disturbances when the oxygen content was above 18%, and the rest, at concentrations below 14%. The maximum functional disturbances appeared in 52% of the subjects when the oxygen content was between 10 and 14%. Tanaka (**118**) used a low-pressure chamber to reduce the oxygen tension in a group of 6 subjects. After 7 to 10 days' practice on the part of the subjects in card sorting, controlled association and memory tests, the experimental series of 4 tests was carried out. In all subjects the maximum impairment was with addition, which occurred very suddenly when the oxygen content fell to about 11½%, corresponding to an altitude of 15,000 feet. At 21,000 feet, or about 9½% oxygen, the time required for simple addition increased, on the average, by 112%. With the same

degree of oxygen tension, choice reaction time was increased by about 40%, while memory was significantly impaired.

Some evidence that the effects of anoxemia may persist is found in the following experiments by Tanaka, who administered the mental tests to his subjects under conditions of increasing oxygen tension after anoxemia; that is, after the oxygen concentration in the experimental chamber had fallen to 9%, or 21,000 feet, oxygen was admitted to raise the concentration to about 10%, equivalent to an elevation of 18,000 feet, at which time the mental tests were again administered. Tests were administered at 3000-foot intervals throughout the entire descending period. In general, the mental performances of both the ascending and descending period resemble each other, although the performance in the descending period, after oxygen deprivation, is uniformly inferior to performance at the same altitude or same oxygen concentration during the ascending period. The cause of this difference may be, in part, the fatigue effect of the experimental procedure or it may be an indication that the effects of low oxygen tension persist for a longer period than has been commonly supposed. McFarland (**70, 73**) has shown that the rate of change in oxygen tension is also important. Rapid changes produce more profound effects than slower changes of an equal amount.

One of the chief difficulties in investigating the effects of changes in physiological functions on mental performance is the effect of practice. If the experimental subjects are put through a training period, it is true that the effects of practice are minimized. However, if practice is continued so that there is no obvious improvement, it is evident that the task has lost much of its usefulness as a measure of excellence of mental performance. In other words, the activity has become firmly established, and the amount of cortical activity represented becomes minimal. Under these circumstances it is questionable whether results from such a test can be taken as an adequate index of mental capacities. Few experimenters have utilized the learning function in their procedures, although an approach to this technique was made by Barach, McFarland, and Seitz (**4**), who found that 3 out of 4 subjects showed a decrease in the number of problems solved on a slide rule and an increase in errors while working for 4 hours in a chamber containing oxygen percentages corresponding approximately to 12,000 feet. In these experiments the detrimental effect of low oxygen was observed in opposition to improvement from learning. McFarland, Knehr, and Berens (**76**) administered 12½% oxygen and 10½% oxygen to a group of 10

subjects and found an increase in the average time for reading 6 lines of print, as well as an increase in the number of fixations of the eye. A definite decrease in the precision of ocular movement was apparent at 12½% oxygen, corresponding to 13,500 feet, and was quite marked at 10½% oxygen, or 18,000 feet.

Lennox, Gibbs, and Gibbs (67) have shown experimentally that there is a sharp decrease in blood flow from the head immediately preceding and accompanying the loss of consciousness. These experiments were carried out in patients in which the record of relative flow of blood through the jugular vein was obtained. Blood analysis shows that unconsciousness results if the oxygen supply to the brain is suddenly reduced to such an extent that the oxygen saturation of the blood in the internal jugular vein falls to 24% or below. In this experiment a direct association is established between degree of oxygenation of the brain and mental function.

Gellhorn and his associates have also studied the effects of changes in the internal environment on mental functions. It was found that auditory and visual intensity discriminations were greatly decreased under the influence of oxygen deficiency, excess of carbon dioxide, or involuntary hyperventilation (31, 37). The latent time of visual after-images was increased by the same physiological changes (38, 40). Various processes, such as association (36), cancellation of numbers (35), and addition of digits (35), were all adversely affected by lowered oxygen tension. The influence of anoxemia on handwriting and memory was striking. Under the influence of anoxemia the handwriting tends to change in character: the letters become larger, more clumsy, lose their individual characteristics, and misspelling occurs. Finally, a state of complete illegibility is reached (33, 34). Similar changes in handwriting are reported by McFarland (69) and by Barcroft (5) in cases of severe carbon monoxide poisoning.

Gellhorn and his associates found that all the sensory and mental impairments which result from oxygen lack were completely alleviated when subjects breathed from 3 to 4% carbon dioxide, even though the same degree of oxygen lack was maintained (32, 33, 34). This is true both of sensory perceptions and of higher mental functions (33), as well as handwriting (33). These experiments show conclusively that a small concentration of carbon dioxide in the inhaled air, which in itself is without any effect on the various physiologic functions and psychic processes investigated, either prevents completely or diminishes greatly the severe effects of anoxemia.

This beneficial effect of carbon dioxide has been found to be due to (1) its stimulatory effect on respiration, whereby the alveolar oxygen pressure is raised and thus a high degree of oxygenation of the blood is obtained; (2) the stimulating effects of carbon dioxide and oxygen deficiency on the vasomotor centers, resulting in vasodilation in the central nervous system, with a resulting increase in blood flow, which thus increases the effective oxygenation of the central nervous system; (3) the effects of carbon dioxide and oxygen deficiency on temperature regulation. These experiments are of far-reaching importance, although numerous physiological aspects of the problem are yet to be solved.

Previously, Schneider, Truesdell, and Clarke (**100**) had found no modification of the influence of anoxemia even when 4 to 8% carbon dioxide was breathed. These negative results may be attributed to the fact that 4 trained subjects, who were accustomed to work in a low-pressure chamber, were used in these studies. Examination of the data shows that a definite increase in respiratory volume was produced by the addition of 4% carbon dioxide. Furthermore, their data show that up to altitudes of 20,000 feet, the alveolar oxygen tension was greater in experiments where carbon dioxide was added to the inspired air in the presence of anoxemia. However, no subjective improvement was reported by the subject, and fainting and a general demoralization of the nervous system occurred in approximately the same atmospheric pressure with carbon dioxide as with the unmodified anoxemia.

Ruhl and Spiess (**98**) found that with carbon dioxide inhalation in anoxemia there is a considerable rise in arterial oxygen saturation, and symptoms of oxygen deficiency both in physiological and psychological tests are reduced.

Kraines (**65**) administered the Army Alpha intelligence test to 30 persons while they were breathing a mixture containing 10% oxygen, corresponding to an altitude of about 20,000 feet, and found a drop in performance of from 1 to 54 points. Subjective estimates of failing ability under low oxygen were found quite inadequate. Since the failing point of performance correlated with the appearance of instability of blood pressure, the author suggested that the efficiency of the cerebral cortex under the stress of anoxemia is dependent upon the ability of the circulatory system to compensate for the diminished oxygen supply.

Similarity between psychological symptoms of oxygen want and certain symptoms of dementia praecox led Hinsie, Barach, Harris,

Brand, and McFarland (52) to subject a series of dementia praecox patients to oxygen concentration of about 50% over a period of 2½ months. Oxygen administration was given daily for varying periods of time. None of the patients showed clinical improvement; however, treatment with carbon dioxide was effective in producing remission of symptoms.

Long-Term Effects of Prolonged Anoxemia

It is well established that persons subjected to diminished oxygen supply over long periods of time will make physiological readjustments which will eventually result in a maintenance of higher oxygen tension in the tissues than that in subjects immediately exposed to the same oxygen concentration in inspired air. This process of acclimatization with a resultant increase in the number of red blood cells circulating in the blood, as well as changes in the vital capacity and respiration, may attain a measurable magnitude even after 12 hours of exposure to lowered oxygen tension. A period of weeks usually elapses before a final equilibrium is attained (71). Numerous studies of the physiological reactions of individuals who have spent most of their lives at a high altitude indicate that acclimatization is never complete—that is, that these individuals never attain as high an oxygen tension in their tissues as do individuals who live at lower altitudes. There is further evidence that the actual tissues of persons living in high altitudes make no adaptations and function at a consistently lower oxygen tension than those of persons living at sea level. However, very few studies of mental reactions and capacities of highland groups have been made.

McFarland (72) compared 35 miners, living at an altitude of 17,500 feet and working in a mine at an altitude of 19,000 feet, with a group of 35 Antofagasta workmen, who were of the same racial stock and average age as the group of miners and who were engaged in heavy manual labor at approximately sea level. It was found that the miners at high altitudes were slower and more variable in simple and choice reaction times than the workmen. Thus, significant differences in neuromuscular coördination were found. Auditory thresholds were higher for the group of miners than for the workers at sea level. This difference, however, as pointed out by McFarland, is quite possibly due to the peripheral effects on the eardrum, with regard to pressure, temperature, and wind, to which the group of miners was exposed. Before any judgment as to the prolonged effect of anoxia on mental performance can be made, experiments in

which a wide range of intellectual capacities are tested in groups which are similar in all respects except altitude at which they live need to be carried out.

It has recently become apparent that prolonged anoxemia of the brain may result in permanent damage to the central nervous system, with attendant mental and motor dysfunction. Clinical reports by Hunt (**61**) and others (**101**) call attention to the frequent association of mental symptoms with pernicious anemia. Since no quantitative measurements of mental performance were reported, it is impossible to evaluate the importance of such clinical observations.

Schreiber (**102**) and Schreiber and Gates (**103**) reported instances of cerebral injury in the newborn due to anoxia at birth. They reported a high incidence of birth anoxia in infants where drugs such as scopolamine or morphine have been administered to the mother during delivery. Eastman (**26**) attributed numerous cases of asphyxia in the newborn to anesthesia of the mother. On the other hand, Ford (**30**) was unable to find any evidence of cerebral lesions in kittens after experimental production of anoxemia at birth. Carbon monoxide administration was also without effect, although the periods of administration were short. Studies of relationship between intelligence or mental development in children and the presence and the use of narcotics at birth have not been made, although such results would be of extreme interest and importance.

Courville (**21**) has collected a series of cases in which severe mental and motor symptoms have developed as a result of asphyxia induced with nitrous oxide anesthesia. Severe degeneration of the brain following nitrous oxide-oxygen anesthesia is reported by Lowenberg and Zbinden (**68**) and by O'Brien and Steegmann (**86**). The augmentation is attributed to anoxemia of the brain. Reports of mental involvement resulting from carbon monoxide poisoning have also been reported (**8**, **78**, **85**). Although the available data are not as complete or as exact as one might prefer, the implication that persistent cerebral anoxia may result in permanent damage to the central nervous system may be drawn. It is also probable that such anoxic insults may be cumulative, thus accounting for the fact that the anoxia produced by nitrous oxide anesthesia may be fatal in one subject while an anoxia of a similar degree has no effect on another patient. It must also be remembered that most of these clinical reports deal with rather marked symptoms which show up in terms of personality disorders or motor symptoms. It is highly probable

that slight deterioration in intellectual capacities may pass undetected. Numerous problems remain for solution in this general field.

Effect of Increased Air Pressure on Mental Performance

Paul Bert (12), in 1878, carried out experiments in which animals exposed to increased air pressures went into convulsions and frequently died. These effects were attributed to the direct toxic action of oxygen in high concentrations. Experience has shown that men who have been working in compressed air, either in diving suits or caissons, are liable, upon their return to atmospheric pressure, to show a variety of symptoms, variously classified as "the bends," "caisson disease," or "compressed air illness." These symptoms are due to the fact that gas, chiefly nitrogen, which goes into solution in the blood and tissues during exposure to compressed air, is liberated in the form of small bubbles if too rapid decompression occurs. The resulting local or general blockage of the circulation may produce a variety of symptoms, depending upon the point at which the block has occurred. Various mental symptoms have been reported subjectively by investigators in this field. Shilling and Willgrube (109) report that men exposed to increased air pressure of 5 atmospheres or above have a definite feeling of stimulation and well-being which they liken to a feeling of drunkenness. At high pressures they have an exaggerated confidence in their ability to accomplish a given task, but to the observer their actual accomplishments fall far short of that demonstrated at atmospheric pressure.

Phillips (88) reports a similar failure of accomplishment, associated with emotional disturbances. Behnke, Thomson, and Motley (11) have published introspective reports of reactions under 4 atmospheres of pressure. The evaluation of the psychic changes was made on the basis of subjective reports. These authors report that visual, auditory, olfactory, and tactile reception were not affected, but the response to these stimuli was delayed. Recollection required greater effort and concentration was quite difficult. Frequent errors in arithmetical calculations were reported, and increased difficulty in laboratory manipulation was found. The retardation of mental activities was reported first at 3 atmospheres; at 4 atmospheres it is a slight handicap; and at 10 atmospheres it may render the individual helpless. Since the breathing of pure oxygen at pressures of 1 to 4 atmospheres, which would correspond to the same oxygen tension in air at 10 atmospheres, does not induce the psychic responses of air under these high pressures (10), the authors conclude that the

increased partial pressure of oxygen cannot be a significant factor in the etiology of the psychological changes. They attribute the effects to the narcotic activity of the nitrogen, which in these high pressures behaves like ether or nitrous oxide, showing a high coefficient of solubility in lipoid matter. Their calculations show that in an air pressure of 10 atmospheres the concentration of nitrogen in the blood is equivalent to the anesthetic concentrations of nitrous oxide at ordinary pressures.

Behnke, Forbes, and Motley (**9**) have shown that oxygen at a pressure of 3 atmospheres can be breathed by healthy men for 3 hours without disturbing symptoms. During the fourth hour, however, a progressive contraction of the visual field, with dilation of the pupils and some impairment of central vision, is the most constant criterion of oxygen toxicity. From these experiments the authors infer that the oxygen acts directly on nervous tissues with a toxic effect. Although the observations reported above are of considerable interest, they do not afford any quantitative estimate as to the extent of impairment of mental performance.

Schilling and Willgrube (**109**) used arithmetic computation, cancellation tests, and light-to-touch reaction time as indices of mental performance in a group of 46 subjects who were subjected to increased atmospheric pressure. The results showed a steady increase in the time required for completing the arithmetic problems as the pressure increased from 100 to 300 feet in depth. Unfortunately, the arithmetic tests were quite short, affording only 19 possible errors, so that the discrimination in these experiments is not as great as is desirable. The reaction time was definitely increased at the higher pressures. Interestingly enough, it was found that, with experience, the degree of mental impairment at a given pressure was decreased. This effect of training was not studied in detail, although it is a subject which deserves attention.

Thus, with respect to introspective reports and quantitative, even though somewhat inadequate, measurements, the conclusion is justified that with increased oxygen tension and air pressure there is a slowing of mental and neuromuscular responses. Because of the difficulties in isolating the pressure effects from the effects of increased oxygen and nitrogen content of the inspired air, no completely satisfactory explanation of the mental effect exists. Phillips, for instance, states that the psychological changes encountered are due to purely mental and not to physical causes. He describes several cases of failure of accomplishment under pressure, which,

through psychoanalytic procedures, were shown to be due to claustrophobia. However, the quantitative measurements of Schilling and Willgrube indicate a reduction in mental performance which cannot be attributed to a purely mental reaction such as claustrophobia.

Behnke, Thomson, and Motley (11) have stated that the psychological changes are due to the narcotic effects of the increased nitrogen tension. However, this is probably not the whole story, since it is reported that the greatest change is noticeable immediately after reaching a given pressure and lessens as the subject becomes adjusted. If the cause were nitrogen narcosis, the psychological difficulties would increase, rather than decrease, with the exposure. The direct toxic action of high concentrations of oxygen on neural tissue is the hypothesis which needs further experimental work. The question whether the psychological effects may be attributed to physical pressure changes has not been separated from the chemical effects of either oxygen or nitrogen. Another explanation of the apparent detrimental effects of increased oxygen content may be the possible increase in carbon dioxide of tissues (**107**). At the high pressure enough oxygen can be taken up in physical solution in the blood plasma to supply metabolic needs, so that the oxyhemoglobin does not become reduced in the tissues. Since oxyhemoglobin is a stronger acid than reduced hemoglobin, the basic ions are not released for combining with carbon dioxide in the tissues as is ordinarily the case. Thus, the carbon dioxide may accumulate in the tissues and central nervous system with detrimental effects on performance.

Acid-Base Equilibrium and Mental Performance

The acid-base balance of the blood is maintained within fairly normal limits in a normal person by the interaction of the respiratory and excretory systems. However, displacements in blood acidity may be produced rapidly by the addition or removal of carbonic acid gas by way of the lungs. When the carbon dioxide content of inspired air is increased, the equilibrium is shifted toward the acid side. Conversely, when carbonic acid gas is removed from the blood by excess ventilation of the lungs, the equilibrium is shifted toward the alkaline side. These changes may take place rapidly over a period of minutes and result primarily in a shift in the acidity or hydrogen-ion content of the blood. Changes in the bicarbonate concentration of the blood may also be effected by the ingestion of acid or alkali. Such changes do not affect the hydrogen-ion concentration as much, and take place more slowly than changes affective through

the respiratory system. Certain relationships between alterations in the acid-base equilibrium and mental performance have been reported. For instance, Gellhorn and his associates have shown that sensory discriminations which are mediated by the cerebral cortex, such as auditory acuity, visual intensity discrimination (**31**, **37**), and visual after-images (**38**), were greatly decreased both by increase and decrease in carbon dioxide content. Other psychic processes, such as formation of associations (**36**), cancellation, addition (**35**), etc., were interfered with under the same conditions. On the other hand, physiological processes involving the lower parts of the brain and not the cortex were enhanced when an excessive amount of carbon dioxide was removed from the blood by hyperventilation (**114**). For instance, vestibular nystagmus, produced in man by caloric stimulation, was increased under hyperpnea, whereas with excess carbon dioxide in the inspired air a decreased number of nystagmic movements was observed (**39**). Since carbon dioxide acts as a vasodilator on the peripheral blood vessels, but stimulates the vasomotor centers in the mid-brain to produce vasoconstriction, Gellhorn explains the impairment of psychic functions in terms of a lowered oxygen supply to the central nervous system.

Although it is possible to explain the deleterious effect of hyperventilation in terms of oxygen deficiency in the cerebral cortex produced by the vasoconstriction which results from the carbon dioxide deficiency, such a line of reasoning will not suffice to explain any detrimental effect of carbon dioxide excess. The detrimental effects of excess carbon dioxide are then attributed to its acid properties. Since carbon dioxide concentration below 3½% to 4% did not produce measurable effects, it is possible that the stimulating effect on the respiration may have interfered with the actual measurement of sensory threshold when used at the higher concentrations where respiration is markedly enhanced. The symptoms of increase in neuromuscular excitability resulting in unconsciousness and tetany have been reported by numerous investigators following hyperventilation (**20**, **43**). Since the acid-base balance of the blood returns to normal values within 1 or 2 minutes after cessation of hyperventilation, although the mental and psychological effects may persist for ¾ to 2 hours (Shock and Hastings, **112**), it is highly probable that the mental effects are the result of cerebral anoxemia rather than the loss of carbon dioxide itself. The cerebral anoxemia could be produced by cerebral vasoconstriction following the decrease in carbon dioxide in the blood.

The effect on mental performance of shifting the acid-base equilibrium by administration of acids or alkalis has been studied by Shock (110). Although significant displacement of the acid-base equilibrium could be produced in either an alkaline or acid direction, significant differences in mental performance, as measured by mental multiplication, were not observed. The negative results of this experiment might have been due to the fact that the experimental subject used had become so proficient in mental multiplication through practice that the test no longer represented mental effort for him. New experiments need to be repeated using a more sensitive index of intellectual capacity and a larger number of subjects.

Effects of Drugs

It is practically impossible to make any adequate generalizations with respect to the effects of drugs on mental performance because of the wide differences of experimental technique, dosages, kinds of animals, and conditions under which experiments were carried out in different studies. Because of limitations of space, only those drugs which are apt to be encountered in everyday existence and on which experimental studies have been made will be considered.

Alcohol

The quantitative experiments on the psychological effects of alcohol are limited to studies which deal with the effect of alcohol administration on the performance in a mental function which has already been learned. The general criticism which can be applied to almost all these studies is that no account is taken of individual differences in absorption. Because of such individual differences, the only true index of changes produced in the internal environment is a chemical determination of the amount of alcohol in the circulating blood. In the studies reviewed, McFarland and Barach's (74), McFarland and Forbes's (75), and Fleming and Goldman's (29) are the only ones in which such an adequate control was made. Most of the studies which attempt to determine the effects of varying dosages of alcohol on mental performance are quite meaningless because no account of body size is taken and because of the wide individual differences in the rate of absorption and elimination.

The experimental evidence which tends to show an impairment of memory and judgment after administration of alcohol is summarized in some detail by Miles (79). In most of the studies reported, the impairment measured is small and is often of questionable statistical significance. Occasionally, individual subjects actually show improvement in some

functions (Miles, **79**). Cattell (**17**) compared the intelligence test scores of 25 men and 25 women without alcohol with their performance on equivalent tests after doses of 10 and 20 gr. of absolute alcohol. Five equal tests of about 110 items were made up and used on 5 experimental days. The experimental procedure was such as statistically to counterbalance extraneous factors. It was found that the 20-gr. dose of alcohol produced only a 1% decrease in intelligence, while the 10-gr. dose produced no measurable change. These results are in accord with the previous study by Hollingworth (**55**), who employed a test of logical relations as opposites and found in the first hour after ingesting 39 c.c. of alcohol (absolute) a decreased efficiency of 15% as compared with normal performance. Administration of 79 c.c. of alcohol (absolute) gave a reduction of 25% under similar conditions. Seward and Seward (**106**) studied the effects of alcohol administration on a group of 12 male students, using, as a test of judgment, accuracy and reproduction of syllogisms of 1, 2, and 3 premises followed by a conclusion. After an administration of .75 gr. of alcohol per kilo of body weight, no effect upon judgment could be determined, although an impairment of immediate reproduction was evident, especially at increasing levels of complexity of the problem. The increase in errors after alcohol administration was statistically reliable, as was the increase in reading time observed. Fleming and Goldman (**29**), in a carefully controlled study, could find no effect of small doses of alcohol on the average mental reactions time. In this study, the test in mental addition was applied at 10- to 25-minute intervals after the administration of the alcohol. Furthermore, the concentration of the alcohol in the blood was determined on each of the 17 subjects. Similar experiments should be carried out in the same way, using dosages greater than the .6 to 1 c.c. of absolute alcohol per kilo of body weight used in this study.

McFarland and Barach (**74**) report impairment of mental performance as measured by choice reaction, color naming, pursuitmeter, batting, and a code test after administration of ¾ gr. of alcohol per kilo of body weight. Actual concentrations of alcohol in the blood were determined at the time the tests were given. When 50% oxygen and 3% CO_2 were breathed, the amount of alcohol present in the blood was reduced, and the impairment in the mental test was significantly less in 4 out of 5 subjects tested. McFarland and Forbes (**75**) found that alcohol produced a greater impairment in auditory threshold at high altitudes than the same dosage produced at sea level. They also showed that the concentration of alcohol in the blood rose more rapidly and reached a higher level at high altitudes than at sea level. Thus, the amount of oxygen available is an important factor in the rate of elimination of alcohol from the body.

From experimental evidence available, we may thus conclude that higher mental functions show impairment when subjected to quantitative measurement, although the relationship between the amount of alcohol circulating in the blood stream and the degree of mental impairment is still uncertain.

Aspirin

When aspirin was administered in medium analgesic doses no measurable effects on mental functions, such as addition, code translations, or opposite tests, were found by Davis (**24**). Similarly, aspirin in 10-grain doses, administered 30 minutes before the test, had no effect on the rate of learning lists of 12 syllables when measured in terms of number of trials necessary for learning (Jones, **63**).

Tobacco

The experimental results on the effect of smoking on mental performance are difficult to summarize because of the different viewpoints and aims of different experimenters. Hull (**59**) attacked the problem primarily in terms of the physiological changes induced by the absorption into the blood stream of substances from the tobacco smoke and took great precautions to exclude psychogenic factors by administering warmed air as a control dose. In other studies, as, for example, that by Fay (**28**), the smoking situation has been regarded as a variable, and no attempt was made to set up control periods under standardized dosage and other physical factors. We are also confronted with studies of the effects of smoking on performance in learned habits as contrasted with studies aimed to test the effect of smoking on the establishment of habits. In addition, differential effects between smokers and nonsmokers are reported. In general, the amount of impairment in learned mental functions is slight and of questionable significance even in nonsmokers (Hull, **59**; Fay, **28**).

Fay found that nonsmokers reacted more slowly to red light for about 5 minutes after smoking began, while regular smokers were little affected. Hull found that mental addition was slightly impaired in nonsmokers, but that with habitual smokers a favorable effect was produced. Fay reported that regular smokers tended to react more rapidly to a choice between red and blue lights for 1 hour after smoking 1 cigarette, while nonsmokers were little affected. He reported large individual differences and wide fluctuations in the reaction time, so that the significance of this finding is questionable. For instance, each subject was given 1 practice session, and the reaction time was taken as the average of 10 trials. It is doubtful whether such a small series would render an adequate index of reaction time for comparative purposes.

Pechstein and Reynolds (**87**) exposed rats to tobacco smoke over a period of 30 minutes to 3 hours daily for 30 to 60 days. The animals were exposed to smoke from 5 gr. of tobacco, so there is no indication whether the effects were produced by nicotine, carbon monoxide, pyridine, or some other combustion products of tobacco. After fuming, the ani-

mals were transferred to the maze, and learning curves were obtained. It was found that rats fumed with a limited amount of tobacco smoke excelled all normal and experimental groups in maze learning. Animals who were fumed over longer periods of time were less effective in learning, with greater variability in the female group. The authors concluded that tobacco smoke to a small degree acts as a stimulant and enhances learning, while excessive smoking depletes learning capacity to the point of inability by the fourth generation.

Using a similar technique for exposing rats to varied degrees of tobacco smoke, Phillips (**89**) was unable to find any statistically reliable difference between experimental and control groups of animals with respect to maze learning ability. In this experiment, groups of animals were placed together in the smoking compartment, so that it is possible that some of the harmful ingredients of the smoke may have been absorbed on the hair of the animal and not inhaled. Furthermore, the animals tended to huddle, which might well have reduced the intake of noxious fumes in the animals at the bottom of the pile. In this experiment, a continuous flow of air was drawn through the smoking chamber so that concentrations of the smoke in various points of the chamber might well have been widely different. In these experiments, as in those of alcohol, analyses of the amount of nicotine or carbon monoxide circulating in the blood of each animal should be made for accurate quantitative work.

Caffeine

Caffeine, when administered as the raw alkaloid or as caffeine citrate, tends to reduce simple motor sensory reaction time from 6 to 8%, depending upon the individual subject (**108**).

Cheney (**18**, **19**) reported that reaction time is reduced more by coffee than by an equal amount of caffeine administered as free alkaloid. Maximum reduction in reaction time occurred between 1½ and 2 hours after administration of caffeine. Reaction time was not affected by a single dose of 3 mg. of caffeine per kilo of body weight. Doses of 3 or 4 mg. per kilo of body weight had a variable effect, while 5 mg. caused a decrease in reaction time over a 3-hour period. Twenty-four hours later the effect had entirely disappeared. Horst and Jenkins (**57**, **58**) reported that 3 to 4 mg. of caffeine per kilo of body weight will shorten reaction time by 2 to 6%. They found that in some of their subjects reaction time was lessened 24 hours after administration of the caffeine. Switzer (**116**, **117**) administered 5-grain doses of caffeine citrate to a group of 25 subjects. Four hours after the drug was given each subject received 16 reinforced conditioned stimuli consisting of a light. From these experiments he concluded that caffeine tends to diminish the inhibitory responses, since the latent period of the conditioned reflex was definitely shortened under the influence of caffeine. The data also tend to show that caffeine augmented the unconditioned reaction of the galvanic skin reflex to electrotactile stimulation. The differential effect of dosage in the case of caffeine is illustrated in a study by Hollingworth (**54**),

who found that the speed of performance at typing was quickened by doses of from 1 to 3 grains of caffeine, although it was retarded by larger doses of 4 to 6 grains. Small doses of caffeine seemed to increase speed and decrease errors in typing, although large doses of greater than 6 grains had the opposite effect. Hull (**60**) administered 5 grains of caffeine citrate to each of 8 male subjects. Three and one-half hours after the administration of the citrate, each subject learned a list of 16 syllables, which were carefully standardized and equated. Although caffeine was found to be associated with an increase in anticipatory displacement in reaction during the learning process, there was a mean reduction in the rate of learning amounting to only 2 to 3%, which was not statistically reliable. Similarly, learning done under the influence of caffeine was relearned slightly more easily than that done after taking a control dose of lactose, but this tendency was not statistically reliable. This experiment was especially well controlled and executed and seems to indicate that caffeine has no significant effect on learning. Cattell (17) administered equivalent forms of standard intelligence tests to a group of 25 males and 25 females, mostly of college age, after they had been given .2 or .4 gr. of caffeine citrate. Even with the smaller dosage of .2 gr. of caffeine there is a slight lowering of average IQ in the group, although the difference is not statistically significant. On the other hand, scores on a memory test consisting of 30 items, which was administered at the same time, improved when caffeine citrate was taken.

The author is of the opinion that there is some indication that men are more susceptible to caffeine and less susceptible to alcohol than women, although the statistical evidence is inadequate. Systematic investigation of the effects of caffeine administered at different stages of the learning process is needed.

Benzedrine

Skinner and Heron (**113**) have shown that administration of benzedrine will cause restoration of a conditioned reflex which has passed through a period of extinction. Twelve white rats were trained to press a lever to receive a food pellet at 4-minute intervals. They found that under standard conditions the rate at which the animals pressed the lever was fairly uniform, even though a food pellet was discharged only every 4 minutes. When the food reward was removed, the rate of pressing the lever diminished. On the eleventh day of extinction ½ mg. of benzedrine sulphate caused complete restoration of the rate of response of the conditioning period. Other experiments have shown that injection of benzedrine actually reduces the hunger drive (**119**), so that the above effect is attributed to the increased motor activity produced by the drug. The problem

of why these motor activities find expression in terms of the previously conditioned response is still obscure.

Bahnsen and Thesleff (2) were unable to establish any significant differences in reaction time after administration of benzedrine. The number of reactions reported was insufficient to establish a stable mean for each subject, so that the results are of little value.

Sargant and Blackburn (99) administered Cattell's intelligence tests to 25 mental patients before and after administration of 20 mg. of benzedrine. A control group which had received a blank tablet in place of the benzedrine showed no change in average score, while the experimental group showed a rise of 3.9 points, or 8.7% in the average score. The author interprets this increase in score in terms of the influence of nonintellectual factors, such as relief from anxiety, mild depression, etc. Molitch and Sullivan (82)[2] tested 96 boys between the ages of 10 and 17 with the new Stanford achievement test. A week later, 50 of the boys were given 10 mg. of benzedrine; the remainder received a blank tablet; all were retested. Twenty-six of the boys, who either lost or failed to improve on 10 mg. of benzedrine, were then given 20 mg. and were retested. Although 8.6% of the controls showed a gain in their scores, the group average dropped 29 points on the retest. Thirty-two per cent of the boys showed a gain on 10 mg. of benzedrine with an average of 63 points, while of the boys who were tested a third time after having been given 20 mg. of benzedrine 92.3% gained, on an average, 117 points in their scores. When benzedrine is administered to normal individuals, reports of well-being, less fatigue, and increased mental efficiency are usually obtained, although Myerson (83) found that in 2 out of 10 cases drowsiness and sleepiness followed benzedrine administration. For instance, Nathanson (84) administered 20 mg. of benzedrine per day to each of 55 normal persons in single test days. Sixty-two per cent reported less fatigue, 56% noted increased talkativeness, while 54.5% reported increased capacity for work. No such reports were obtained from a control group of 25 subjects who received similar tablets containing calcium lactate. From these experiments the author concludes that the drug should be of value in the preparation of individuals for activities that require unusual expenditure of physical and mental energy.

Gwynn and Yater (45) administered 20 mg. of benzedrine per day to each of 147 medical students over a period of 3 days. A control dose of lactose was administered. After administration of benzedrine 113 of the group reported that they felt peppy; 72 reported that they became exhilarated; 42 reported that they were more talkative; 61 reported greater powers of concentration; 126 suffered from insomnia. No tests of actual performance were given. Similar stimulating effects, based on subjective reports of 10 normal persons, are reported by Davidoff and Reifenstein (23). In comparing these results with those obtained with the administration of benzedrine to psychotic patients the authors con-

[2] The same data are presented by Molitch and Eccles (81).

clude that benzedrine is apparently more stimulating to normal persons than to depressed or self-absorbed patients, and that it is more effective in increasing motor activity, speech activity, and general efficiency than in elevating the mood.

The stimulating effect of benzedrine on motor activity is confirmed by Zieve (**122**), Searle and Brown (**105**), and Brown and Searle (**14**) in their studies on rats. Brown and Searle found that when the drug was given every fourth day to a group of 15 white rats, the spontaneous activity of the animals was markedly increased, with a maximum in the first hour after the injection, falling off rapidly to normal or subnormal values within 4 hours. Doses of 3 mg. per kilo gave greater stimulation than did 1½ mg. per kilo or 4½ mg. per kilo of body weight. Bradley (**13**) administered 20 mg. of benzedrine sulphate daily to each of 30 children between the ages of 5 and 14 who were referred to a clinic for behavior problems. The intelligence of the group was, in general, within normal limits. During a week of daily administration of benzedrine 50% of the children showed a marked improvement in school performance. They report that the effect appeared within 45 to 50 minutes after the benzedrine was given, reaching a maximum during the second or third hour and disappearing within 6 to 12 hours after. Schube, McManamy, Trapp, and Myerson (**104**) administered benzedrine to 80 patients from the psychiatric clinic of the Boston State Hospital. The subjects were distributed among all psychoses and were given 10 to 30 mg. of benzedrine daily for 30 days. The authors found no improvement in any of the cases studied, and in 15 cases a temporary accentuation of the psychosis. Similar reports are given by Davidoff and Reifenstein (**23**), who found increased motor activity, increased speech response, and improved general efficiency in a group of dull, self-absorbed, negativistic, shy, reclusive, inactive, and resistive mental patients after 3 weeks' treatment, but little effect on mood.

The subjective reports of increased mental efficiency given by normal subjects after the administration of benzedrine are not borne out by quantitative measurements of output in the experiments of McNamara and Miller (**77**), who found that the number of problems of written multiplication of two 3-digit numbers was not materially increased nor were the errors affected even though subjective feelings of stimulation were reported. Barmack (**7**) found that administration of 10 mg. of benzedrine to each of 36 students increased the number of problems of adding pairs of 6-place figures attempted, but had no effect on errors.

Although most experimenters report increased feelings of well-being and increased motor activity in normal persons, results from psychotic patients failed to establish any marked alterations in mood. Consequently, the conclusion of Sargant and Blackburn that the improvement in intelligence test scores is due largely to nonintellectual factors is open to question. More experiments in which quantitative measures of mental output are used in normal subjects, including children, are highly desirable.

Phosphate Administration

The interesting possibility of inadequate dietary intake of inorganic phosphate contributing to fatigue, lassitude, and lowered intelligence of school children is raised by experiments carried out in Germany. During the War Embden (**27**) reported that he had experienced a mental freshness and euphoria, at a time when he usually felt sleepy, by the ingestion of moderate amounts of primary sodium phosphate or recresal. Poppelreuter (**90**) made the first systematic investigation to show the effect of phosphate administration on mental activity. He used 2 groups of experimental subjects who carried out continuous additions for periods of 3 to 5 hours. The author claims that without exception the intake of recresal resulted in an increased quantity of work as well as a decrease in the number of errors. Unfortunately, this study was inadequately controlled in terms of the effects of suggestion, since it seems likely that the purpose of the test was soon discovered, especially by the 5 psychotechnicians who served as subjects.

Griesbach (**44**) studied the effect of recresal administration on multiplication and division work in a group of bank clerks. No significant differences were found resulting from recresal feeding. Dahmen (**22**) attempted to find out whether there were any differences in the effect of recresal when it was used continuously and when it was given in a single dose. His test consisted of tachistoscopic perception, a mental activity which seems particularly ill-advised since it is practically free of mental work. In no case did he find a decrease in efficiency after recresal administration. In 2 cases the results were doubtful and in 4 cases, favorable. Since no control tablet was used, the factor of suggestion was not excluded. Since the mental test chosen was ill-advised, the results of this experiment are of little value.

On the other hand, Rahm (**96**) carried out an extensive experiment under very rigorous control but could find no evidence of an increased mental efficiency with the administration of recresal to adults. In the case of children, single doses of recresal failed to show any augmentation in mental performance. However, after recresal had been taken for a number of weeks an increased efficiency was observed in mental activity as measured by mental addition, preassociation, and a cancellation test. In control experiments he found that the effects of suggestion were of considerable magnitude. It was found that, after the proper suggestion, both recresal and the sham drink produced an increase in efficiency. After the intake of recresal the performance in general was not greater, but often even less, than after the intake of the sham drink. On the other hand, the intake of caffeine showed increases in efficiency that were considerably greater than those obtained in the suggestion test. Since it is known that children are by far more suggestible than adults, it is possible

that the beneficial effect of recresal which is reported for children was primarily an effect of their greater suggestibility.

Strauch (**115**) reports an improvement in school work and general health in a group of school children following the administration of small doses (1 grain) of monosodium phosphate or recresal with each meal. No standard tests or control groups were tested, so that the scientific value of his experiments is not great.

In summarizing the experimental results of phosphate feeding on mental performance we may say that objective proof of its stimulating effect is still lacking but that the tendency for positive results to appear with children is interesting and requires further controlled experiments.

Carbohydrate Metabolism and Mental Performance

Since it has been shown that the only source of energy available to the central nervous system is in the form of carbohydrates (**49, 50, 51, 56, 66**), the correlations between lowered blood sugar levels and mental performance are of interest. Hoelzel (**53**) reports increased mental efficiency after short fasts which he correlates with low values of blood sugar (0.43 mg. per cent). These subjective reports are not in accordance with the objective tests administered by Glaze (**41**), who found a decrease in all mental tests in his study of fasting. As yet, no controlled laboratory studies exist to show a relation between blood sugar level and mental performance in humans, although the speculations of Barcroft (**6**) are suggestive.

Experiments with animals have shown that, when the blood sugar level is reduced slightly by small injections of insulin, conditioned reactions are augmented. Heron and Skinner (**48**) trained rats to press a lever to obtain food. One hour after the injection of .02 unit of insulin the time required to establish the habit was reduced by 31%. In a similar experiment, using the same type of problem and apparatus, Wentink (**119**) found a reduction of 26% in time required 1 hour after injection of .005 unit of insulin in rats. It is quite probable that this augmentation in learning is more the effect of increasing the "hunger drive" in the animal than of change in glucose available to its central nervous system, and it has been shown repeatedly (**16, 25, 95**) that small doses of insulin produce hypertonus and hypermotility of the stomach, which is the physiological basis of sensation of hunger. Since wide individual differences in sensitivity to insulin exist, it is important that blood sugar values be obtained in order to draw conclusions in such experiments. Furthermore, the maximum effect of insulin on blood sugar usually occurs

shortly after intravenous injection. In both the above experiments interpretation is further complicated by the fact that the insulin injections were subcutaneous, thus introducing a further variable of rate of absorption. A systematic investigation of the entire problem is needed.

Rose, Tainton-Pottberg, and Anderson (97) found that a series of convulsive administrations of insulin restored a conditioned response in sheep. The conditioned reflex of the sheep had been studied over a period of 7 years, but during the last year the reflex had gradually failed. Convulsions were induced on each of 7 successive days by the administration of insulin. During the period of insulin shock no reflex could be elicited, but 1 hour after administration of glucose by mouth the conditioned reflex, absent for almost a year, reappeared with abnormal vigor. The augmented reflex persisted over a period of 2½ months. No interpretation of this experiment is made by the authors in their preliminary report, but it is evident that the augmentation effect cannot be attributed to the immediate effects of lowered blood sugar, since during this period no response could be elicited. After restoration or augmentation of the blood sugar by glucose administration, the response was enhanced. Suitable controls to show that the effect cannot be attributed to the immediate rise in blood sugar were not reported, but it is presumed that the effect is produced by some long-term effect of the insulin shock. It is possible that the effects are due to some permanent damage to the higher centers resulting from low sugar and O_2 of the blood, with attendant removal of inhibitory effects of these higher centers, although more experiments are needed before satisfactory conclusions can be drawn.

One of the chief physiological effects of epinephrine is the increase in blood sugar which is produced by relatively small injections. Hence, it may be well to discuss the effects of injections of adrenaline on mental performance under this section rather than in connection with drug or endocrine factors.

Heron and Skinner (48), as well as Wentink (119), have reported that adrenaline caused a 25 to 30% decrease in rate of response in rats previously trained to a motor act as described in a preceding paragraph. The results are interpreted as due to removal of the hunger drive of the animals resulting from the inhibition of gastric motility following administration of epinephrine. However, Heron and Skinner report a short period of increased rate of response immediately following the injection, although no such period of increase

was observed under similar conditions by Wentink. Thus, the results obtained are equivocal.

In these experiments, the habit was established, and the drug effects studied referred to alterations in motivation for the performance of the habit. Experiments on the effect of adrenaline on mental performance in humans have been carried out by Jersild and Thomas (62). In 6 subjects intramuscular injection of 7–16 minimum of 1:1000 solutions of adrenaline chloride decreased performance in substitution, free association, mental calculations, and color-naming tests, although speed of tapping and muscle strength were improved.

The effect of adrenaline on learning ability has been studied in some detail by Akimov (1), who reported an accelerative effect on maze learning in rats. With food as the motivation, the augmentation in learning is the more surprising, since hunger was presumably reduced by the injection. Groups of 9 to 18 animals were tested under different conditions, and it was found that ½ c.c. of 1:500,000 adrenaline, beginning on the eleventh day of learning, increased the learning rate more than when adrenaline was administered from the first or sixth day of learning. Adrenaline 1:500,000 was more effective in stimulating learning than was adrenaline 1:100,000 or the administration of electric shock. The control group of animals which received daily injections of normal saline did not learn as quickly (measured by trials or errors) as those receiving adrenaline injections, but was significantly better than the control groups which received no injections. The author attributes the improvement to increased tactile sensitivity in the rat as an aid to his learning. However, a more plausible explanation is that the emotional stimulus of receiving an injection, even of saline, stimulated the animal to release adrenaline from its own adrenal glands. Hence, we must attribute some synergistic influence of slight doses of adrenaline to the learning process. This study is one of the few reviewed in which any assessment of the effect of time of injection and dosage on learning was made.

The hypothesis that mental diseases may be due to cerebral malnutrition resulting from hyperinsulinism has been an attractive one (Harris, 46, 47; and Powell, 91, 92, 93, 94), although such a theory has yet to receive adequate confirmation.

Powell (94) reported an interesting relationship between blood sugar levels and mental performance in a group of 3 patients. In a girl of 12 years of age Powell found that mental performance as measured by school

work in spelling was markedly improved when the blood sugar level, which in most tests hovered around 50 mg. per cent in this patient, was raised to approximately normal value of 120 mg. per cent by the frequent feeding of high-carbohydrate food. Maximum results were obtained when the school tests were given at the time when the blood sugar was high. The same spelling test, given 2 hours later when the sugar level had dropped back to the low value of about 60 mg. per cent, shows a definite decline from the score when the blood sugar was elevated. The cause of hyperinsulinism is obscure, but the author tended to attribute it in part to the high sugar consumption and the result of continued stimulation of the pancreas. Interesting as this case may be, more experiments with a rigorous laboratory control and standardized procedures for testing mental performance are necessary before a final judgment can be passed.

Considerably more information is available with regard to the long-time effect of disordered carbohydrate metabolism. Joslin (**64**) stated that "one-third of our diabetic children are of superior intelligence." This statement is based on the results of giving the Stanford-Binet test to 169 diabetic children.

A detailed study of the same 169 diabetic children was made by White (**121**) in Joslin's clinic. An intelligence quotient above 110 occurred in 23%, of from 90 to 110 in 54%, and below 90 in 13% of the children. Seventeen children from 1 to 6 years of age were tested with the Binet test, and in this group, 9, or 53%, had an IQ from 90 to 100; 2, or 12%, had an IQ below 90; and 6, or 35%, had an IQ above 110. The range was from 84 to 143, with a median of 108. Mental deterioration occurred in 4 of the diabetic children studied, all with onset in infancy; but in 2 of these cases definite cerebral trauma from infection occurred. From these results White concluded that in the period of life in which mental growth was increasing at a rate far exceeding that of the older child, the diabetic had better than the average intelligence, proving that diabetes is not a handicap to mental progress.

Miles and Root (**80**) administered a series of psychomotor tests, such as mental addition of numbers and cancellation of digits, to a group of 40 adult diabetic patients and compared the results with a control group of adults of the same age. They found that diabetic patients frequently complained of poor memory and power of attention but failed to find objective proof of any deficiency. However, diabetic patients with hyperglycemia and glycosuria at the beginning of treatment showed a decrement of about 15% or more in memory and attention tests. With treatment, the diabetic improved rapidly in his psychological status, approaching, but not quite reaching, normal. West, Richey, and Eyre (**120**) administered the Stanford-Binet test to 76 juvenile diabetics and found that the IQ of the diabetics showed a somewhat higher average than that of normal

children, although there was considerable variation. Improvement in diabetes did not raise the IQ, and when the diabetic control lapsed the IQ tended to remain unchanged or to rise. Since a socioeconomic selective factor may operate when diabetics under treatment are studied and compared with the average population, the previous studies need a more adequate control of this factor. Such a study has been reported by Brown (**15**), who compared mental-test data of 60 diabetic children with similar test data obtained on 28 siblings of the diabetics. In order to minimize the possibility of subsequent development of diabetes in the sib controls, the next older rather than the next younger child to the patient was chosen for the control group. It was found that the group of diabetic children was distributed quite normally as to intelligence, with 43% of the diabetics within the IQ-range of 90 to 100 and approximately equal numbers above and below. Both the mean and the median IQ are almost exactly 100, as compared with a median IQ of 106 for the siblings. No relationship was found between duration or severity of the disease on the one hand and intelligence on the other. School achievement and behavior of the diabetic group compared favorably with that of their siblings in spite of poorer school attendance. It is suggested that the high percentage of bright children in Joslin and White's (121) diabetic group may be due in part to the high percentage of Jewish children among their cases and in part to the selection of those patients from the upper socioeconomic groups.

From these studies we may conclude that objective evidence for the superiority in intelligence of diabetic children is lacking.[3]

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[3] A brief summary of the literature on endocrine factors in mental growth and development has been recently published by Shock (**111**). A more complete review of the influence of endocrines on mental performance is in preparation.

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INDEXING THE *PSYCHOLOGICAL INDEX* [1]

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A brief note in a recent number of the *Psychological Bulletin* referred to the "Psychological Index Project" conducted under the Works Progress Administration in New York City. As this project has developed into one of large proportions, and is one which is expected to benefit psychologists everywhere, it seems fitting to give a brief account of its history, its present status, and its probable eventual outcome.

I. History

The difficulty of locating references in the *Psychological Index* in the absence of anything but a very general classification of subjects in each volume, contrasted with the great convenience of a cumulative author index of all volumes maintained in the Department of Psychology at Columbia University (and probably in certain other universities), inspired one of the authors years ago to entertain the idea of a cumulative *subject index* covering all volumes of the *Psychological Index*.

The need for such an index was felt keenly by C. M. Louttit while he was preparing, with the support of the National Research Council, his *Bibliography of bibliographies* (1928). Shortly thereafter, a plan for a cumulative index began to take form in his mind, and in the spring of 1933 he conferred with one of the writers, then the Chairman of the Division of Anthropology and Psychology of the National Research Council. The idea of such an index was discussed from time to time with many psychologists, editors, and publishers. Estimates of the magnitude of the task, ways in which it might be worked out, and the probable cost were obtained from

[1] This work is financed and operated by the Works Progress Administration of the City of New York, Professional and Service Division, as part of Official Project # 465-97-3-18, Bibliographies and Indices of Special Subjects.

various interested persons during 1933. It appeared from preliminary surveys that if the actual indexing were to be done without charge by psychologists, the total cost of the project including printing would be about $25,000, and the probable returns from sales would be about $7,000, leaving a balance of $18,000 to be provided. In spite of the need for such a large subsidy, the proposal met with enthusiastic and almost unanimous support. It seemed that the next step should be the presentation of a fairly detailed proposal to the American Psychological Association. This was done in the fall of 1934.

The Council of the Association acted upon the proposal by referring it to the Board of Editors of the Psychological Review Publications for report at the 1935 meeting of the A.P.A. The Board of Editors, in turn, appointed the following committee of 3 to study the proposal: W. S. Hunter, Chairman; H. S. Langfeld; and C. M. Louttit. This committee reported to the Board of Editors in March, 1935, the result of a canvass of psychologists in 21 universities, showing 101 for, 36 against, and 28 doubtful. After considering the probable limited distribution of the Index in the form in mind at the time, and the probable cost of editorial work, manufacture, and distribution, the Editorial Board presented the following recommendation to the Council of the A.P.A.:

> "That it is the opinion of the Board of Editors and their advisors that, in spite of the strongly favorable vote, it would be inadvisable on account of the large deficit to publish the cumulative index of the *Psychological Index*."

When presented by the Council to the business meeting of the A.P.A. in 1935, the resolution was adopted.[2]

Although the proposal was thus officially disposed of, for the time being at least, the further decision of the Association at the same meeting to discontinue publication of the *Psychological Index* with the 1936 number made the whole idea of a cumulative index seem more desirable than ever;[3] for it would then be possible to prepare

[2] See Proceedings of the Forty-third Annual Meeting of the American Psychological Association, *Psychol. Bull.*, 1935, **32**, 649–663.

[3] The Association showed its continuing interest in the project, however, by appointing upon recommendation of the Council, at the 1938 Annual Meeting, an advisory committee to work with the project directors of the Indexing Project. The committee consisted of A. T. Poffenberger, K. M. Dallenbach, C. M. Louttit, and R. R. Willoughby. Although no funds were provided for meetings of this committee, the members have frequently been called on for counsel and assistance in determining policies.

a final and complete Index covering the entire 42 volumes, with never any need for revision or supplementation.

II. Planning of the Project

The matter rested thus until the fall of 1936, when representatives of the Works Progress Administration in New York City invited one of the writers to present an outline of a project that would give employment to a considerable number of unemployed psychologists, translators, research workers, and high-grade clerical workers, and at the same time have an outcome whose value could not be questioned. The Indexing Project was tentatively offered and accepted, as it seemed to satisfy these requirements, and particularly as it fitted conveniently into a program of bibliographic research (Bibliographies and Indices) which formed a part of one large white-collar division of the W.P.A. (Research and Clerical Division). Dr. Louttit, upon being informed of the successful negotiations with the W.P.A., expressed delight that his brain child should be adopted under such favorable auspices.

In conformity with W.P.A. regulations the original setup was as follows: Sponsoring Agency, New York State Psychiatric Institute (such projects must have a tax-supported institution as official sponsor); Coöperating Agency, Columbia University; a director; a project supervisor and assistant supervisor; 10 head research workers and 60 research workers and translators; 5 stenographers, 5 library clerks, and 3 typists. The detailed program to be formally presented to the Planning Section of the W.P.A. for consideration and approval was prepared by Dr. S. B. Sells, who was thoroughly familiar with the organization of such projects and who served as project administrator during the early stages of the program.

The original plan called for indexing the 107,226 references found in the *Psychological Index* from 1894 to 1928, inclusive (overlapping the *Psychological Abstracts* by 1 year), with an average of 2 index entries for each item. The indexing technique was to follow that used in the annual index of the 1936 volume of the *Psychological Abstracts,* except that any article would be located by volume and reference number in the *Psychological Index,* thus:

Stutterer, association in, group influence, 35:1640

meaning that the reference would be found in Volume 35 as reference number 1640. Minimum intelligence and educational requirements were specified for the different grades of workers, and minimum psychological training for those concerned with reading and classi-

fying. Each worker was to go through a training period and be tested before actually beginning productive work.

Productive work did not get under way until June 18, 1937. In the meantime, many puzzling and troublesome problems had to be studied and overcome. Some of these called for radical changes and improvements in the program.

1. The most serious and persistent problem was the finding of competent workers who would at the same time be eligible for employment by the W.P.A. Although one of the original purposes of the project was to employ psychologically trained persons who were sorely in need of work, few of these seemed to have been reduced to such financial straits as to be actually on Home Relief rolls. Furthermore, it became clear very early that competent technical supervisors could not be found on the relief rolls. It was decided, therefore, to begin operations with a very limited staff in the hope of building it up gradually. On July 1, 1937, 19 persons were at work: 11 research workers and 8 administrative and clerical workers. It has been possible since that time to build up gradually an excellent staff with adequate special training and with competent supervision. The staff at present comprises 65 workers: 1 director, 2 assistant project supervisors, 2 psychologists, non-relief, 26 research workers, 16 translators, and 18 clerical workers.

2. The limited utility of the finished product was a matter of much concern during the period of planning, since the Index would have to be used in conjunction with the volumes of the *Psychological Index*. A search among cumulative indices in other fields suggested that reference might be made in each case directly to the source without making the printed document too cumbersome. Particularly encouraging was the *Index of Geological Literature of North America*, covering the period from 1785 to 1918, with both author and subject index, and printed in 1 volume of about 1200 pages. It appeared from our calculations that the whole subject index could be printed on about 1200 pages, 3 columns to the page, if the references were to be cited in some brief form such as the following:

Stutterer,
association in
group influence J. Ab. Soc. Ps. **23**, 45 [4]

The project was, consequently, modified to conform to this new plan.

[4] In order to save space, the shortest and most simple forms of citation of journals are to be used.

3. One of the earliest decisions concerning the technique of indexing was that it could not be adequately done from the title of an article alone. Some examination of the article itself would be needed. The original plan, therefore, called for the reading of an article by the research worker and the selection by him of the indexing cues. All research workers were to be given training and tests for proficiency in reading and indexing by having all of them read and index the same selected series of articles. These results were to be brought together and discussed with the group, pointing out inadequacies and showing the correct indexing. Preliminary results of this training were somewhat discouraging and led to a modified procedure as follows: The function of indexing was separated from that of abstracting. One group of research workers now read the article and prepared an abstract of it in accordance with instructions given in a 25-page abstractor's manual, supplemented by interviews. This abstract was to be sent on to trained indexers who would make the classifications, decide upon cross references, etc. The training given to the indexing group will be described briefly in (4).

4. The first intention to use the index number of Volume 10 of the *Psychological Abstracts* as the model for classification of the material was supported by opinions from the Library of Congress, the New York Public Library, and the H. W. Wilson Company. However, serious criticisms came from the editors of the *Psychological Abstracts,* who had developed its index and who pointed out numerous shortcomings in it. Preliminary indexing had also suggested that the system, though valid for 6000 references published within a year, would be quite inadequate for 107,000 references spread over 35 years. The whole question of a proper indexing system for psychological material was therefore reopened for systematic study and a more thoroughgoing system developed (see Section IV). This was prepared in the form of a 24-page manual which served as a textbook for training the indexers. All prospective indexers, 40 in number, were required to attend a study course of eight 6½-hour days at which 96 abstracts were read, indexed on the blackboard, and thoroughly discussed under the instruction of R. G. Wetmore. The course was concluded with an examination. The indexing staff of 13 was chosen from the persons standing highest in the examination.

5. The references contained in the *Psychological Index* undoubtedly vary widely in their importance and particularly in their significance for psychologists. In recognition of this fact the suggestion

has frequently been made that material from remotely related fields and material that is trivial be ignored in the preparation of the Index. This calls for an exercise of judgment for which the project director did not wish to take the responsibility. What is insignificant at one time may become significant at another, and what is only remotely related to our field at one period may, at another, come to be closely related. Moreover, it is often necessary to know the inadequate attacks upon a problem in order to avoid similar pitfalls in later work. Finally, there is something to be said for completeness if the final index is to be called an *Index of the Psychological Index*. It has been decided, therefore, to index all references, in the face of estimates of several psychologists that from 10 to 25% of the material could be disregarded.

III. Project Operation

The operation of the project may best be presented by outlining the work flow by which a reference passes through the successive processes of preparation, assigning, abstracting, indexing, editing, typing, and filing. The present tense is used throughout, although the first phase has been completed and the last not yet begun.

a. *Preparation.* References cut from the pages of the *Psychological Index* are pasted on 3 x 5 cards, called work cards. The volume number is stamped immediately on the upper left corner of the card, above the reference number on the pasted slip.

b. *Sorting for Assigning.* Work cards are sorted by languages and, within each language, into journals and books. Library locations are stamped on the journal references. Books are looked up in library catalogs by clerks, who record on the cards the call letters and the library or building in which the book may be obtained.

c. *Assigning.* Work cards are assigned to research workers and translators by one man in accordance with their interests, abilities, and knowledge of languages. The assignment packs of about 80 cards are recorded (by volume and reference number) in the work-record book of the particular assignee and are held at the assignment desk until that worker's next scheduled office visit, when they are "dated out" and delivered to him with a record of their number.

d. *Abstracting.* After obtaining the original article or book at the Forty-second Street Public Library, Columbia University, Academy of Medicine, or Psychiatric Institute, the fieldworker checks the accuracy of the printed reference and writes a summary of the article on the back of the card

For the purposes of this project, a highly specific abstract or summary is necessary. A check (duplicate abstract) on about 4% of the abstracts submitted to date has shown a high reliability in the work. Fieldworkers have been trained to give content, not topic; to restate, not to characterize; to give what the author says, not what he talks about. For experimental articles, method (or apparatus or both), subjects, results, and conclusions are specified. Abstracts are noncritical and nonevaluative except in one case: "Although the author may be vague, your abstract should be clear and definite, even to the point of stating his vagueness and the precise issue on which he is vague" (*Abstr. Manual,* p. 19). Discrepancies between title and content are clearly indicated.

About one-third of the assigned cards bear a notation indicating that a published abstract will be found in, for example, *Arch. f. d. g. Psychol.* Ansbacher's idea and method of utilizing these already available summaries has resulted in a considerable saving of time, particularly in the case of summaries of foreign books and articles. Plans are now under way for the publication of lists of published abstracts either as a volume of about 150 pages or in such form as to permit their insertion in bound copies of the *Psychological Index.*[5]

On his next bi-weekly office visit, at which time his abstracts are inspected and criticized, the fieldworker returns his completed cards to the assignment desk with a work record indicating the amount being returned and the balance still in his possession. Returned cards are checked in the record book, and an entry is made on a monthly record sheet from which individual production records are obtained.

e. *Indexing.* Abstracted cards are filed in numerical order by volume number. Cards are assigned by topic to 3 psychologists who, in turn, distribute them to the indexers in their respective groups. The indexers write the indexing formulae (see C, Section IV) and index entries on 5 x 8 sheets, making liberal use of dictionaries, chiefly Warren's, and of a card file of accepted terms, and return the cards and index sheets to the psychologists.

f. *Editing.* The 3 psychologists carefully edit the cards, examining the summary when indicated, checking summary and entries against title, returning a card for a new abstract or for additional information where necessary. The corrected index papers are then

[5] Abstracts have been discovered for 19,000 out of the 40,000 items in Volumes 26 through 35 of the *Psychological Index.* Lists of this material are ready for publication, and those for the remaining volumes will be ready shortly.

discussed with the indexers for the purpose of obtaining, so far as possible, uniform accuracy and maximal consistency of indexers and editors.

g. *Typing.* The indexing formula, from which all index entries are derived, is then typed on the original work card, and each entry is typed on a separate 3 x 5 index card, together with the abbreviated reference. All index cards are proofread twice.

h. *Filing.* Index cards are then filed alphabetically, forming a part of the final index.

IV. Indexing

The indexing phase has been the most awkward to standardize, largely because of the difficulty of isolating the various aspects of the task. The 2 broadest aspects which, for the purpose of this project, it has been necessary to separate are (1) the formal indexing system to be used and (2) the concrete working-procedure to be followed in its application.

1. The formal indexing system, to be handled mainly by the 4 psychologists, must provide:

a. criteria for the selection of concepts to be indexed;

b. criteria for the selection of words, labels, or terminology for these concepts;

c. a system of cross-referencing (use of *See* and *See also* references) to correct for the scattering which necessarily results from indexing under specific headings.

2. The basic activities involved in indexing a single book or article are shown by job analysis to involve 3 logically separate tasks:

a. selection of concepts, phenomena, or subject matter;

b. selection of words, terminology, or labels for the concepts;

c. arranging and writing these words into index entries.

These operations, being performed by 13 indexers, have been routinized and simplified by (1) analyzing concepts and words into 3 types of "terms" and (2) supplying a notational system for their representation in an "indexing formula," from which all individual entries for a given article may be derived.

This method of indexing by formula [6] has proved workable in the teaching of indexing and has the following advantages: (a) it provides a standard form in which the judgments are to be expressed; (b) it

[6] The major work of devising and standardizing the method has been done by R. G. Wetmore. In passing, it may be mentioned that 2 indexers of the *Encyclopedia Britannica,* who appraised the indexing manual, recommended the publication of the "formula method."

compels consideration of the whole subject matter and organization of the article, thus maintaining relations; (c) it breaks up the complex job of indexing into 2 independent operations: writing the formula (what to index) and writing the entries (how to index it).

Usually the subject matter of a book or article is fairly definite and can be broken down into a limited number of terms in outline form. Three types of terms are distinguished: definitive, limiting, and relational terms.

A. A definitive term represents a concept of primary importance in the article and (often, but not always) in psychology and science. It may be a broad major concept in psychology (learning), a highly specific one (retroactive inhibition), or (less frequently) not a "psychological" term at all, *e.g.* a disease, drug, occupation, organ, animal, religion, proper noun, etc. Thus, in an experimental article the chief ideas which must receive definitive status are (a) the organism studied (if significant), (b) the dependent variable(s), and (c) the independent variable(s). In short, a definitive term may be anything with which the writer was primarily concerned and which represents a proper topic of research, discussion, or study in its own right. It is represented by a capital letter. It is a single concept, but not necessarily a single word. It is always indexed as a heading.

Thus, an article on the intelligence of Navajo Indians contains 2 definitive terms, *Intelligence* and *Navajo,* and the formula is A+B. An article comparing Intelligence among Irish, Germans, Danes, and Americans contains 5 definitives, but in accordance with the Class-Member Rule (more than 3 members of a class assume the class name), the last 4 terms are represented by their class term, *Nationality.* The formula is A+B, and the definitives are *Intelligence* and *Nationality.*

B. A limiting term is one which, *in the article,* modifies, qualifies, or limits *one* definitive term. It marks off a part, type, application, or aspect of the latter's subject matter. The limiting term is not necessarily an adjective. Usually its significance is dependent on the definitive term. It is represented by a numeral written as a subscript to the letter which it limits, as A_1. It is never indexed as a heading. In the index entry it must necessarily follow its definitive.

The following illustrate A_1 relations:

Humor
  subject matter
  theory
Learning
  laws of

Blood pressure
  rhythm
  variability
  measurement
  graphic recording

The following types of apparent A_1 relations are actually designated as compound definitives and are rewritten as such or expressed in a single term, in accordance with these 2 criteria: (a) the compound must "hang together" as a single stable concept, not readily decomposable and not a mere phrase; and (b) it must be in common use in the literature:

Intelligence
defective: .....equals.....Hypophrenia
mechanical: .....equals.....Mechanical intelligence
test: .....equals.....Intelligence test

Adjustment
capacity: .....equals.....Adaptability
social: .....equals.....Social adjustment

Color
vision: .....equals.....Color vision

Blood
pressure.....equals.....Blood pressure

C. A relational term is one which limits or relates to *more than one* definitive term. Examples are correlation, phylogeny, theory, review, and debate. Frequently a relation is understood, implied, or expressed by a particle (in, and, *vs.*), and no relational term is required.

The writing of the formula and, from it, the entries is illustrated below:

Formula	*Entries*	
Crime rate humidity A 1 B	Crime rate humidity	Humidity crime rate
Crime type season A 1 B	Crime type season	Season crime type
Neurosis therapy case A 1 2	Neurosis therapy case	
Eidetic imagery age blind A B C	Eidetic imagery age and blind	Blind eidetic imagery age and
	Age eidetic imagery and blind	

It is understood that no indexing rule or formula is absolute in its application, or universal in its scope, and that judgment can

never be entirely eliminated from the task of indexing. Nevertheless, it is believed that the present methodological system will provide for efficient and consistent indexing.

V. Prospects for Completion of the Project

During the course of this project the persons concerned with it have become increasingly aware of the magnitude of the task. No standardized techniques for such work seemed available anywhere which could be adopted wholesale. New and puzzling problems have been and still are being met. An index which shall be near perfect is still the goal. Progress has been slow, and discouragingly so at times. At present the abstracting is somewhat more than 50% complete; the indexing from these abstracts has only recently been started. But the necessary organization of staff and procedure is complete, and the indexing principles have been worked out and have been taught to the workers. There should now be a rapid acceleration of production, barring unforeseen obstacles.[7]

The specific problems of publication are still to be directly faced. Numerous possibilities for printing and methods of financing have been examined. A single volume of a size not too large for convenient use will contain the subject index. A companion volume of equivalent size containing an author index can be readily prepared from the data accumulated for the subject index. Although the latter has not been officially recognized as a part of the program, its publication should be kept in mind.

[7] There is the ever-present uncertainty concerning the continuance of any W.P.A. project and concerning the continuance of the W.P.A. itself.

SPECIAL REVIEW

WOODWORTH'S EXPERIMENTAL PSYCHOLOGY[1]

BY JOHN F. DASHIELL

The University of North Carolina

It was a news item of much more than ordinary interest to the psychological world when the announcement was made that "the bible is out," for the word had been awaited for some years not only by the Columbia doctorates but by psychologists everywhere. The thorough competence of its author in almost any field of the subject, as revealed to anyone who has read and heard and interviewed him, coupled with a heavily-ballasted tendency to keep to his middle-of-the-road while also appreciating the views down the by-lanes, and, withal, a simple clarity of exposition, assured an eager public for his *magnum opus*. And now, after several months of examination and use, what is that public's judgment? Does Woodworth's *Experimental psychology* measure up to expectations? Does it reveal competence of grasp, understanding, knowledge? Does it maintain balanced viewpoints? Does it expound complexities simply? It does. Such, at least, is the definite impression received by one member of the psychological public, who has delayed setting down his opinions until he could give the book a tryout as a teaching instrument.

But to take up these points in the reverse of the order of mention—and of importance. First, we have Woodworth's style again. The clarity of his revision of Ladd's *Elements of physiological psychology*, the simplicity of his elementary *Psychology* and his *Care of the body*, and the freshness of treatment of his *Dynamic psychology* are here again. There will be those who feel that he might have stuck closer to certain traditions in verbal usage that make for formal precision. Why, for instance, entitle chapters in an imposing *Experimental psychology* as "The Skin Senses," "Smell and Taste," "Hearing," and "The Sense of Sight," when we have the more formal and scientifically conventional names of the 'cutaneous,'

[1] R. S. Woodworth. Experimental psychology. New York: Holt, 1938. Pp. xi+889.

'olfactory and gustatory,' 'auditory,' and 'visual'? Still better, why enumerate the psychophysical methods as "the adjustment method," "the method of serial exploration," and "the frequency method" (pp. 395 ff.), when through the years we have known them by other labels—and, particularly, when the very name, 'psychophysical,' has only an historical justification, and the whole field of research is highly formalized.

There are many expressions encountered which are not precisely and stiffly scientific yet are clear enough, and will probably not worry any but the more severe stylist. The following are examples: Müller and Schumann found that alliteration, assonance, or rhyming "made a soft spot in a list" (p. 13); in a blood pressure study "the use of 12 mm as a critical value separated the sheep from the goats" (p. 274); investigators of cold spots "have been on the watch for end bulbs but have not seen any" (p. 463).

The outstanding point about Woodworth's style, however, is that it is readable, and this despite the fact that it is reviewing technical topics, and in a meaty way, so that the reader quickly finds himself immersed and swimming with the current in a stream of factual discussion, all unawares of how he got there. The first-year graduate student no less than the middle-aged experimentalist is likely to find that this book, taken up for an hour's study, will threaten his sleeping program.

Maintenance of a point of view is a consideration of less importance to the author of a work on experimental than to a writer in almost any other psychological line of interest. Yet a curiosity as to coverage and as to organization naturally arises. As will be evident from the chapter titles to be furnished below, the coverage is far more complete than in any other "experimental psychology"—old or recent. No major field is neglected. To this the lone exception is the topic of work and fatigue, as acknowledged by the author, to which, by contrast, Bills, in his *General experimental psychology*, devoted 120 pages, and Robinson, in the "Handbook," gave 80.

The order of topics is not conventional—if there be any such thing—but the placing of chapters on memory and other phases of learning was to be expected by those who had seen the mimeographed pages in use a decade and more ago in the Columbia laboratory. In any case, the matter is of scant importance, for the chapters can be used (as the reviewer has found) in almost any order to fit a particular course of study as already organized.

A fact of major significance is that Woodworth makes very few

references to the physiological facts and problems that tie in with many psychological problems, so that his book is far different from the *Handbook of general experimental psychology,* issued by the Clark University Press. In the reviewer's opinion this will have a salutary effect: Many readers and an eminent reviewer of the "Handbook" were so impressed by the detail of material of physiological nature included therein that they felt somewhat apologetic about psychology as a science supposed to stand on its own feet. Experimental psychology, we are now reminded by Woodworth's book, can be psychology and can be experimental without having to lean on physiology. The point is the more impressive when we remember that the author himself came over into psychology from physiology and is known as an author in both sciences.

In its manner of treatment, Woodworth's *Experimental psychology* does not conform to any of the more familiar types. It is not a reference handbook, aiming at completeness of citation and at utter thoroughness of detail of fact (though there are something like 1731 titles in the bibliography). It is not a laboratory manual, describing instrumentation and recommending specific procedures (though the Müller-Urban table of weights is furnished, and broad hints and precautions in laboratory setup are introduced in connection with PGR, chronoscopes, tachistoscopes, and elsewhere). It is not an historical survey (though some historical orientations, like that to reaction time, are strikingly effective). It is none of these kinds of 'experimental psychologies.' It seems designed essentially as a textbook for the advanced student and incidentally as reading for the mature experimentalist. The present reviewer has found it the first adequate answer to the need for a wide range of reading matter to accompany the laboratory training in a graduate experimental course. As said, it is not a manual; and the instructor will have to organize his own course and plan his own experiments and apparatus setups—which is well-nigh the universal practice anyhow. But he can now devote himself to that laboratory work with confidence that the reading materials will take care of themselves.[2]

Our first question is the hardest for a reviewer to attempt to answer. To pass upon the competence of treatment in the many fields that are included in this book is a task that might well be

[2] Attention should be directed to G. R. Wendt's monograph (Methods of recording action. *Arch. Psychol., N. Y.,* 1938, No. 228), originally planned as an appendix to the Woodworth book, in which principles of apparatus construction and employment are set forth.

assigned a board of critics who have specialized in their respective lines. The present reviewer will, then, content himself with a series of notes, chapter by chapter, as they present themselves to a psychologist who cannot go back into the references to verify all restatements and interpretations nor always evaluate competently the author's choice of materials.

I. *Introduction.* The reader is introduced to the experimental method as one that emphasizes controls that affect independent and dependent variables. The interdependence of experimental and statistical procedures is pointed out; and a Fisher reference is given, though not his *Design of experiments.*

II. *Memory;* III. *Retention;* IV. *Memory for Form.* The general topic of learning is allowed to fall apart into the historically distinct topics of laboratory investigation in separate chapters. In Chapter II a few more suggestions on apparatus would have been helpful, for surely one of the hardest problems for the general laboratory is that of providing memory apparatus that is sure-fire, simple, and rugged; and all the ingenuities of series-building, time-spacing, and the like come to naught when an exposure apparatus skips a beat or fails one. Ebbinghaus is, of course, the point of departure, and the range of problems and methods is fairly adequately covered. Eidetic images are included, in a factual treatment rather than a theoretical exposition, beyond the statement that the eidetic child "sees objects rather than masses of light, shade, and color" (p. 46)—which is peculiarly in line with some other Woodworthian emphases to be mentioned.

The wide range of material on retention (from which only Luh's differentiation of measurement methods was seriously missed) is so assembled without forcing as to throw doubt on the theory of a physiological consolidation process. This is shown especially in the moot question of reminiscence. It is a bit startling to read that the relations of memorizing, retention, recall, and relearning may be likened to the relations that can be traced in the response of the muscle to exercise and rest (p. 60), and a bit dangerous, too, as we know from the adoption of the analogy by the ancient 'formal discipline' (p. 177).

In Chapter IV is an excellent example of studies from a wide range, all presented for their own value, yet also, without forcing, serving as evidences pro and con on a quite fundamental problem: Wulf's theory that the memory trace tends toward "better figure." The reader, then, is afforded a good review of the more significant

research done, is acquainted with important theory, and has a viewpoint mildly suggested. Incidentally, here is Woodworth's characteristic sympathy and grasp of a new viewpoint, without his becoming stampeded by it to the left or bending backward to the right.

V. *The Conditioned Response.* This chapter is comparable with Hull's chapter in the "Handbook," for, though not quite so complete in citations (some 70 references as against 119), it is as satisfactory for orientation and for analyses of the problems, especially 4 years later. Of note is the recognition of differences, recently come home to us, between 3 sorts of conditioning experiments as represented by those of Pavlov and Liddell (no avoidance of US), of Culler and associates (avoidance of US by the CR), and of Skinner (CR produces US) (pp. 102 ff.). A good point on the development of drowsiness appears in the statement that each trial, on which the animal is fed only a small amount, really involves a premature cessation of feeding. A lesser-known method of inducing neurosis appears in the experimental disruption of a salivary CR by building up too strong a shock. No mention is made of Steckle and Renshaw's experiment contradicting Hudgins' conclusion: Is that question settled? A ventilation and broadening of the concept of CR incidentally results from the manner of treatment, and comes out clearly in emphases upon attentional and attitudinal factors (pp. 99 f., 109 ff.) and upon the conditioned withdrawal as not a particular movement so much as a withdrawal from a particular object (p. 123).

VI. *Maze Learning.* Why this should be included and not discrimination learning—both coming from the animal laboratory and both most fruitful there—is not at once apparent. True, the rat-in-the-maze furnishes the most used analogy in theorizing on learning; yet the discrimination habit is coming into its own in work upon equivalence of stimuli and sense-perceptual problems. A refreshing side to this chapter is Woodworth's hypothesis of place learning, which shifts emphasis from the motor components of an activity to the objects or situation with which it deals, found also in his treatment of the CR in the preceding chapter. One wonders, however, if he is not dealing with a straw man in his handling of the 'motor pattern theory' which he identifies with the Watsonian chain reflex: Must a motor pattern be an invariable one?

VII. *Practice and Skill;* VIII. *Transfer of Training;* IX. *Economy and Interference in Learning and Remembering.* Neither in preceding chapters nor here do we run into the law of effect. As has been the case with most of the other explanatory principles of selec-

tion and fixation that used to grace our texts on learning, has this one, too, been weighed and found wanting? It must be that he has misgivings about the trial-and-error doctrine itself, for it gets no mention until a very late chapter in the book (XXIX), where his survey of animal experiments fails "to reveal any case where either insight or trial and error was present" in its extreme form (p. 762). Omission of the law of effect may be associated with Woodworth's acknowledged omission of research on motivation (for the reviewer believes that recent work is linking the two closely). To be sure, nearly all the clean-cut work on motivation as a factor in learning has been conducted in the animal field, but the findings are highly suggestive for human psychology.

Cross-education is included (starting with Weber!), though some would question its strict relevance to the problems as usually conceived. Swift's curves for ball-tossing are reproduced without Peterson's correction thereof, but the omission may be justified since they are used as evidence for cross-education, not for positive acceleration. The Poffenberger-Wylie-Bruce interpretation is happily included. As for certain distinctions that have been magnified in the literature: 'abstract' principles are, after all, concrete bits of behavior (p. 207).

Chapter IX is limited to recitation, massed *vs.* spaced, whole *vs.* part, interference, and retroactive inhibition. Studies on the last-named are reviewed as favoring either the interference theory or the anticonsolidation theory.

X. *Feeling.* This is a short chapter on introspective analyses, with particular attention to Nafe's characterizations of bright and dull pressure. Woodworth "wonders whether Nafe's original experiment would give the same result in other laboratories" (p. 238) and offers the conclusion, though "not exactly forced by the evidence," that feelings are reactive attitudes (p. 241). This chapter will surely strike conservatives as a bit too summary; and for the many subtle ramifications of feeling problems and their interpenetration with other phenomena one will want to keep Beebe-Center's book at hand.

XI. *Expression of the Emotions;* XII. *Bodily Changes in Emotion;* XIII. *The "Psychogalvanic Reflex" or "Galvanic Skin Response."* "So far definite, dependable symptoms of feelings have not been discovered. From the original point of view the method of expression has broken down" (p. 235). This statement in the preceding chapter apparently concerns the elementary feelings only; for

in this and the 2 following chapters methods of expression are given generous space (12 pages on facial expression). Vibrato makes its entrance here instead of in connection with esthetics later, but which way the Iowa laboratory would have it may be debatable.

"Statistically, the I/E ratio is not a very good measure. It is all right for single cases but not good for averaging, when the single ratios differ considerably. . . The I-fraction [here recommended] is obtained by dividing the duration of inspiration by the duration of the whole cycle" (p. 262). True, the I/E ratio has no upper limit, while the I-fraction has the virtue of varying only between .00 and 1.00; but the skewed character of breathing-cycle curves should render the latter inadequate also. Simple physiological and apparatus notes are furnished to orient the student regarding respiratory rate and amplitude, the I/E ratio, and circulatory volume, rate, and pressure; but there is scant attention to the problem of motor patterns. The history of attempts, from Féré and Wundt down to the present, has indeed furnished a procession of failures; but at least our one apparent achievement, the startle pattern, might be proudly displayed.

Woodworth's preference for 'psychogalvanic reflex' over the 'galvanic skin response' is likely to be frowned upon; but if we are to have more modern terminology why not go the whole way of Ruckmick's "electrodermal response"? The "rudiments of the necessary technique" do not include mention of the tachogram, electronic methods, or reflexohmmeters. Space is given to a physiological discussion of 6 pages (probably the longest in the book), that does not overbalance 13 pages of psychological queries.

XIV. *Reaction Time.* Here is one of the best examples of historical orientation, done apparently casually but putting the reader abreast of all the significant questions; and the whole chapter is Woodworth at his best.

XV. *Association.* Following XIV, the topic of association is treated quantitatively as well as qualitatively and clinically.

XVI. *Experimental Esthetics.* After a description of the methods of impression procedures available, results on color and visible form are set forth.

XVII. *The Psychophysical Methods;* XVIII. *Results in Psychophysics: Judgments of Magnitude.* The only topic in the book that is presented too abruptly is that of the methods of psychophysics, where, if anywhere, deliberateness is to be sought. The queries concerning this and that variation in procedure are rather inclusively brought to the reader's attention; but in some ways the treatment is

likely not to be as successful as, for example, Guilford's, in his *Psychometric methods.* The 'reaction time method in psychophysics' is included—at the expense of the more classical methods of equivalents and of equal sense-distances.

XIX. *The Skin Senses;* XX. *Smell and Taste;* XXI. *Hearing.* Woodworth's freedom from too much bias by his reaction conception of psychology is revealed by the dominant place given here to introspective analyses and classifications. Indeed, Henning's work gets nearly 10 pages of pros and cons, an overgenerous amount; and adequate presentations of analyses by Stevens, Rich, Köhler, and others crowd descriptions of the physical-physiological work of Wever and Bray, Fletcher, Kreezer, Davis, and others. Is localization of sound a sensory or a perceptual problem? At least it is awarded 16 pages in this context. The term "quality difference" when referring to physical stimuli is likely to be misleading (p. 521) and is probably a slip. The meaning of "decibel" is not made too clear (pp. 437, 505).

XXII. *The Sense of Sight.* Again the phenomenal aspects of sensation are given major treatment, starting from Katz's varieties and including 6 pages on after-images and their explanations. But the stimulus correlates of many sorts of visual phenomena are not neglected. Woodworth is not invariably happy in his substitution of new names for old, but 'duplex' for 'duplicity' in translating Von Kries's *Duplizitätstheorie* seems eminently sensible.

XXIV. *Perception of Color;* XXV. *The Perception of Form;* XXVI. *Visual Space.* Problems of color constancy, especially the modifications of illumination factors, receive a 20-page treatment, through which Woodworth's (James's) view of perceiving as a perceiving of objects emerges at times, but unobtrusively. Unobtrusively again, it appears in the canvass of the leading problems in form perception, which are set up each in its own right and not as the product of the Gestalt or any other school. The geometrical illusions, stereoscopy, and distance cues appear in their conventional way, with stress laid upon the visual as against tactile-kinesthetic cues. The phi-phenomenon is not exploited beyond 2 condensed paragraphs, for some reason.

XXIII. *Eye Movements;* XXVIII. *Reading.* Two models of presentation that tie in together.

XXVII. *Attention.* "Besides this inclination [on the part of Titchenerian, Gestalt, and other psychologists] to place a taboo on the concept of attention, there is an obvious difficulty in segregating

certain experiments under this title. . . Yet these experiments have distinctive characteristics which ought not to be obscured" (p. 684): span of apprehension, shifts, fluctuations, distractions, simultaneous performances.

XXIX. *Problem Solving Behavior;* XXX. *Thinking.* Except for Chapter V and some of Chapter VI, Chapter XXIX contains the only considerable inclusion of research work on animals and children, due to the fact that that is where the fundamental concepts have largely arisen or at least have been experimentally formulated and tried out. History is incidentally set straight with a query as to "whether or not this motor conception of trial and error is precisely what Thorndike meant" in his original monograph (p. 752), and with Hobhouse credited with origination of the methods of string-pulling, reaching-stick, 2 sticks, footstool, and others of the sort. "Köhler's criteria [for insight] of suddenness and smoothness" are, in fact, not always maintained by him, as Woodworth would seem to imply (p. 761). Gibson and McGarvey had said in their review of experimental studies of thought and reasoning that "less ingenuity in inventing methods seems to have been exerted in this field [of thinking] than in almost any other" (*Psychol. Bull.*, 1937, **34**, 344). The judgment still seems borne out by the survey Woodworth gives us, for after the 'free report' studies 2 decades ago by the Würzburg School, Binet, Bühler, and himself, Selz's is almost the sole contribution, if we except those on concept-forming and other forms of induction. Particularly is there a crying need for experimental attack upon the creative processes, which get recognition here in their case-method form. However, this impression of a paucity of laboratory work which the reader gets from Woodworth's final chapter may be exaggerated by the scattering of some relevant studies in other chapters, and by the omission of references to research on the ultimate nature of 'silent thinking' or 'inner speech' through the avenues of action-current and other muscular recordings—which is apparently too physiological for inclusion.

Through this running account the reviewer has tried to imply that Woodworth's *Experimental psychology* is astonishingly complete in its coverage—despite his having had to withdraw a substantial amount of his completed manuscript; that it is remarkably well balanced in its distribution of attention to all the topics of the conventional field of 'experimental psychology'; that it is as unbiased and fair a review as seems humanly possible; that he who seeks the

author's own interpretative viewpoints can find them suggested here and there quite unobtrusively but forming a consistent pattern. For the psychologist's reading shelf—or better, his desk—it is item No. 1. For the teacher of a course in 'experimental' it is an answer to prayer.

The publishers are to be congratulated on a first-class bookmaking job. The absence of the titles to journal articles listed in the bibliography is somewhat tantalizing, and could have been gotten into much the same space by a reduction in type size for that section. Italics for statistical symbols, and italics or quotes for words and syllables referred to as such in the text, would aid the reader. Publishers' conventional setting of figures at the middle of pages sometimes throws them out of place with the text. But these are insignificant! More important are the large, clear type on excellent paper, generous employment of center and side heads, clear figures, and a binding that is rugged, handsome, and moisture-resistant.

BOOKS RECEIVED

GILLILAND, A. R., & CLARK, E. L. Psychology of individual differences. New York: Prentice-Hall, 1939. Pp. xvi+535.

GOULDEN, C. H. Methods of statistical analysis. New York: Wiley, 1939. Pp. vii+277.

JALOUX, C. E., *et al.* Le mystère animal. ("Présences.") Paris: Plon, 8, Rue Garancière, VI^{e}, 1939. Pp. ix+301.

NETZER, R. F. The evaluation of a technique for measuring improvement in oral composition. *Univ. Ia Stud. Educ.*, Vol. X, No. 4. Iowa City: University, 1939. Pp. 48.

PRATT, C. C. The logic of modern psychology. New York: Macmillan, 1939. Pp. xvi+185.

SPECIAL NOTICE

After June 20 all manuscripts, books for review, and correspondence concerning the *Psychological Bulletin* should be sent to the editor, Professor John A. McGeoch, at the Department of Psychology, The State University of Iowa, Iowa City, Iowa.

NOTES AND NEWS

At the meeting of the Society of Experimental Psychologists in Princeton, April 3–4, the fourth award of the Warren Medal was made to Dr. Carlyle F. Jacobsen for his "Description of the Function of the Frontal Lobes of the Brain."

Dr. Frank N. Freeman, professor of educational psychology at the University of Chicago, has been appointed chairman of the department of psychology. Concurrently with the appointment, the department has been transferred from the Division of Biological Sciences to the Division of Social Sciences. Professor Freeman succeeds Professor Harvey Carr, who retired last autumn. In the interval, Professor Louis L. Thurstone, Charles F. Grey distinguished service professor of psychology, assumed responsibility for the administrative details of the department pending the appointment of a chairman. The transfer of the department to the Division of Social Sciences for administrative purposes was made because Dr. Freeman is connected with that division. The field of interest of the department will continue to be in both biological sciences and social sciences.—*Science.*

Dr. Norman R. F. Maier, assistant professor of psychology at the University of Michigan, who received the award of $1,000 of the American Association for the Advancement of Science at the Richmond meeting, has received from the university the Henry Russel Award for 1938–39 in recognition of his scientific work. The Russel award and the Henry Russel lectureship were made possible by a bequest of the late Henry Russel, of Detroit, an alumnus of the University of Michigan. —*Science.*

Dr. R. S. Sackett, who has been assistant professor of psychology at the American University, has accepted an appointment as research associate with the Educational Motion Picture Project of the American Council on Education, Washington, D. C.

The Society for the Psychological Study of Social Issues has been granted $1,000 by the William C. Whitney Foundation for the support of its research activities during 1939.

The Fifth International Congress for the Unity of Science will be held at Harvard University, September 3–9, 1939. A number of general sessions will be held on such themes as "The Logical Unity of Science," "Cosmology and Physics," "The Relation of Biology and Psychology," and "The Place of the Social Sciences and Humanistic Sciences in the Edifice of Science." Information may be obtained from the American Congress Headquarters, Department of Philosophy, University of Chicago.

THE Washington-Baltimore branch of the American Psychological Association held its third meeting of the year at the George Washington University, Washington, D. C., on March 15. The following program was presented:

MITCHELL DREESE: "A Comparison of Methods of Administering and Scoring the True-False Test."

THELMA HUNT: "Psychological Studies of Patients Undergoing Frontal Lobotomies."

MADISON BENTLEY: "Wish, Wisdom, and Experiment in Psychology."

A NEW psychological laboratory has been opened at the University of Alabama, as part of the recently established department of psychology in the College of Arts and Sciences, which first offered courses in psychology in September, 1937, under the direction of the present chairman, Professor Donald A. Ramsdell. The stock of apparatus includes a necessary nucleus for courses in experimental and physiological psychology, demonstrations in elementary psychology, as well as equipment for a limited amount of independent experimentation. Dr. John T. Cowles has immediate charge of this laboratory. Visiting psychologists are welcomed cordially.

THE *Journal of Consulting Psychology* announces that the entire set of photographs of applied psychologists which appeared in Volumes I and II of that journal is now available. These photographs, reproduced on 100-pound gloss-finish paper, are 7½ by 10 inches and are suitable for framing or, if desired, they may be tacked directly to the wall.

The psychologists whose pictures are in this series are: W. V. Bingham, J. McKeen Cattell, Douglas Fryer, Henry H. Goddard, Leta S. Hollingworth, A. T. Poffenberger, Lewis M. Terman, E. L. Thorndike, L. L. Thurstone, Lightner Witmer, Robert S. Woodworth, and Robert M. Yerkes.

These photographs will be sent postpaid on receipt of $1.50. Single copies are 50¢ each. Checks should be made payable to Jack W. Dunlap, Treasurer, A. A. A. P., and sent to the University of Rochester, Rochester, N. Y.

THE summer meeting of the Rocky Mountain branch of the American Psychological Association will be held at Boulder, Colorado, about the middle of July. Members and Associates of the American Psychological Association who will be in the Rocky Mountain area during that time are invited to contribute papers and participate in the meetings. Titles and abstracts of papers should be sent to Dr. George T. Avery, at Fort Collins, Colorado, by June 15.

THE International Committee has voted to hold the next meeting of the International Congress of Psychology in Edinburgh in the summer of 1940.